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State of Tennessee Data Center Statement of Requirements Conceptual Drawings

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IBM Corporation

CONTENTS

1. PROJECT OVERVIEW

The State of Tennessee, Office for Information Resources (OIR) engaged IBM to take the results of a Gartner Disaster Recovery study, showing the need for two data centers for business continuity, and develop a first level conceptual architecture, timeline, site evaluation and project budget. Tennessee intends to construct two new, stand alone data center buildings based on a Statement of Requirements Report that was developed by IBM. Each building will be approximately 35,000 square feet (SF) in total area with 15,000 square feet of raised floor. Each will be constructed within a 25 mile radius of each other and of the existing data center in Nashville. Four sites have been tentatively selected as candidates for the construction project to be completed over the next 5 years.

The need for two buildings, each with 20,000 square feet of raised floor was initially identified in a January 2006 Gartner Inc. Business Continuity and Disaster Recovery report. The Gartner recommendations were for a dual data center solution located within a limited distance (25 – 40 miles) to facilitate the recovery of applications in the event of a disaster at one of the data centers. The existing data center is not a suitable solution due to power and building structural concerns.

To achieve a reasonable balance of disaster recovery capability and project cost, Tier III buildings, as defined by the Uptime Institute, were used as the basis for this effort. A Tier III facility minimizes downtime by the use of resilient systems. Dual electric and communications feeds to the building, reduction of single points of failure in power distribution and cooling are elements of a Tier III design. In Tennessee, with tornados being the major threat, enhanced wind resistance must be designed into each building.

The State of Tennessee's team identified and evaluated multiple potential sites as candidates for the two data centers. Based upon screening criteria derived from the requirements associated with Tier III reliability, seven existing parcels of land in the Nashville area were reviewed. IBM has evaluated and scored and made recommendations for each property. Of these seven sites, four parcels were determined to be the better locations and cost estimates to develop these sites were provided. Three of the four are on existing State-owned property at the RS Gass boulevard location and the Ellington Agricultural Center site. The fourth site is privately owned and located in Smyrna.

The site evaluations are presented in detail in section 7 of this document. The top ranked site is the RS Gass Boulevard Masonic Home location followed by the privately owned Smyrna location and the state owned Ellington Center. The second RS Gass Hilltop location is ranked fourth. Based on our findings, IBM feels that two State of Tennessee owned sites, RS Gass – Masonic Home location and the Ellington Agricultural Center, and the Smyrna Jones Property Regional Airport location should be pursued to construct the two data centers. Budgetary cost summaries for the building are presented for all four locations. Three sites are listed so that one site can serve as a backup location, should one of the first two choices develops a problem.

The Statement of Requirements details IBM's recommendations for the physical data center facility design specifications for a data center of a Tier III level. The raised floor space, critical electrical and cooling support systems are sized for future growth and a future modular increase to even greater IT facility support requirements. For example while cooling systems will be installed to meet the anticipated near term (5-10 year) load, the chilled water pipes installed as part of the initial construction are sized to support additional cooling systems anticipated over the next 20 years. The same principal was applied to the electrical distribution system.

The anticipated gross area of each building is approximately 35,000 square feet. The new data center will accommodate some office space, the 15,000 SF raised floor data center, and required support areas. The estimated population is up to 47 people over three shifts. To minimize the expense, the basic structure of both buildings is the same. One of the two buildings is planned to accommodate a Command Center with an additional maximum 25 people, with the other building housing a print facility.

The overall design objective is to obtain a new facility that is functional, efficient and architecturally expressive of the functions housed within while being sensitive and supportive of the existing community and context of the area surrounding this site.

Budgetary cost estimates are presented for each of the locations. Depending upon the site that is selected for each of the buildings, the budget costs can range from approximately $17,800,000 to $25,900,000. Factors affecting the project estimates are the site acquisition and preparation costs, and the command center / print facility.

The purpose of this engagement was to refine the requirements, develop conceptual system descriptions and budgetary estimates. The design effort of this engagement is limited to a conceptual building and floor plan, and the single line electrical and mechanical drawings necessary to define the scope and budget for the effort. Drawings are found in section 8 of this document, which describe graphically the building space and a possible IT equipment layout; the critical electrical power and cooling systems; and the location of the building on the four sites.

2. DESIGN NARRATIVE

PROJECT DESCRIPTION:

The focus of this project has been to assist the State of Tennessee with developing a detailed Statement of Requirements for two new Data Center Facilities located in or around Nashville, TN. IBM worked with Tune Design Architecture and the State of Tennessee to identify the physical requirements for the design of this new facility, develop conceptual building and site drawings, and estimate construction costs and schedule for the new Data Center Facilities.

1. ARCHITECTURAL AND INTERIOR DESIGN:

Given the “mission critical” nature of the facilities and its contents, the State of Tennessee Data Centers are first and foremost envisioned as a successful environment for computers; One that provides the system redundancies required for efficient, continuous, uninterrupted operations and communications.

A quality data center must also provide a successful environment for the people responsible for its operation. The office and support spaces should offer relief from the artificial environment of the computer room by emphasizing daylight, visual contact with the outside and more humanizing elements.

The siting of the facility will respect its surroundings. It is anticipated that the new data center will be a stand-alone building but will be strongly influenced by the context of surrounding areas. Generous open spaces and landscaping will soften the impact of the center even further. The exterior materials are envisioned to be brick and decorative masonry units with concrete block back-up, storefront glazing, solar louver shades and composite metal panels. These materials will be articulated to maintain the scale and character of the surrounding area.

A secure equipment yard will be constructed to provide security for outside equipment.

2. SPECIAL STRUCTURAL CRITERIA

Slabs on grade shall be designed for a minimum 150 psf live load and the concentrated wheel load of an 8000 pound fully loaded lift truck. Standard foundations are anticipated with drained granular fill beneath slabs and vapor barrier. It is recommended that no live load reductions be taken for data center floors.

Lifting support structure shall be provided for equipment parts requiring removal for maintenance such as chiller heads, pump casings, etc. These loads shall be factored into the roof structure or be provided by a separate structural support system above mechanical equipment rooms. In addition, the roof structure shall be designed to support special loads imparted by hanging pipe supports.

Any spray applied fireproofing of steel structure, if required, should be a high density cementitious product that has a sealer to minimize the risk of flaking and delamination.

BUILDING SHELL

1. EXTERIOR WALLS

Data center exterior walls shall provide adequate protection from temperature, humidity and moisture, and shall serve as a security barrier against intrusion. Thermal criteria shall be minimally in accordance with ASHRAE Standard 90. The degree of security protection will be determined based on an overall site security risk assessment conducted by State of Tennessee security staff. The exterior architecture will be designed to be compatible with the other community buildings. Exterior wall construction components shall be designed to be a brick with block backup or other “hardened” wall systems that provide adequate impact and intrusion protection appropriate to the site.

2. FENESTRATION

Optimum outside awareness shall be provided at office and public support areas with high performance, insulated store front glazing.

There are limited glass penetrations at the computer room walls placed to provide some interior visual communication between certain spaces.

3. ROOF

Basic elements of the roof design shall include minimum 1/4 inch per foot slopes to drain and complete vapor barrier protection above the data center space. The roof will be sloped to the exterior walls to eliminate internal drainage through the data center space. Equipment traditionally located on the roof surface will be located on the surrounding grade areas instead of on the roof wherever possible in order to minimize roof penetrations into the data space.

The roof materials consist of a light weight concrete on metal deck with three-ply modified bitumen roofing system. Due to the critical nature of the building contents, water tightness is of utmost concern hence roof material are recommended to be the highest quality the project can afford. The roof will be designed for tornado uplift.

4. BUILDING MODULE

The building should have a structural frame design that will establish an interior building module that will integrate ceiling and partition systems, office sizes, corridor dimensions, lighting, etc. The recommended computer space planning module is 2’-0” x 2’-0” which coincides with the raised access floor panel sizes. The current concept plan is based on a bay spacing at the computer area. If possible, the data center will be adjusted to minimize columns within the space in order to maximize flexibility of the rack layout. The one-story solution benefits from larger bay sizes, since the columns only support the lighter roof loads instead of floor and roof loads.

Building Circulation and Cores

1. Aisles and Corridors

A circulation system of primary and secondary corridors has been defined in the concept stage. Corridors will be constructed of fire rated drywall partitions and heavy use areas, such as the loading dock, storage and staging shall be constructed of concrete block.

2. Toilets

Toilet rooms shall have ceramic tile floors and walls and ceiling hung toilet partitions are recommended. Toilet accessories shall be stainless steel toilet fixtures shall be vitreous china commercial grade and counter tops shall be plastic laminate finish.

3. Janitors' Closets

Provide janitors' closets with terrazzo mop basins and storage shelving for cleaning supplies. Consider placing hot water heaters here to minimize piping runs to the restroom lavatories.

4. Break Room

The design anticipates providing a vending employee break room area along with required utilities for the machines, a refrigerator, microwave oven and countertop with sink. Incorporate with break room / lunch room seating area where possible. This area must be attractively designed to provide visual relief for employees as well as efficient food dispensing. It is assumed that vending services within the data center will be most useful for employees. Provide seating capacity for 8-12 people.

5. Telecommunications Room

The telecommunications room / area located on raised floor will serve as a switchboard for all cabling from internal and external services of data processing to all end-users within the building.

Building Functions

1. Entrances and Lobby

A single visitor's entrance security control point shall be developed at the lobby of the building. The reception area must provide an inviting, attractive entrance for the facility while providing security from unwanted visitors and operating security system monitoring systems. The program has allowed for a small, modest lobby since visitors will not be regular or plentiful.

A single employee entrance with secure sallyport should be provided, if site constraints allow, off of the employee parking lot. All entrances must be accessible by the handicapped. Entrances to the facility should be kept to a minimum for adequate security control. All exterior doors will require security badge access or remote door control from the security desk.

2. Offices

All offices shall be modular in dimension and shall conform to State of Tennessee standards. It is anticipated that the vast majority of office space will be open workstations. Minimizing the number of office sizes will allow for maximum flexibility and simplified rearrangement.

3. Conference Rooms

Conference room partitions shall be insulated with sound absorbing wall materials from floor to underside of structural deck above and shall be finished in accordance with State of Tennessee standards.

4. Raised Floor Area / Computer Rooms

Provide raised floor area with minimum 30 inches free access floor. A depressed structural slab is intended for the slab-on-grade data space in order to avoid ramped access.

Raised floor panels are recommended to be supported on a rigid stringer understructure system that provides floor stability even when many floor tiles have been removed for underfloor servicing. Floor covering must be high-pressure laminate. Concrete filled panels are recommended for all machine areas.

5. Loading Dock / Shipping and Receiving

This function must have direct proximity to the truck dock and to the service access into the computer room for ease of equipment delivery and service. A small receiving area is included in this space including area for staging of equipment.

6. TRUCK DOCK

The truck dock is anticipated to have 1 truck bay, 13’-0” wide minimum, sized for 55’-0” long tractor-trailers. Hydraulic powered dock levelers area recommended. A separate area should be dedicated to the placement of the trash compactor-container with access to the hopper directly from the dock surface. The program requirements for recycling and short term deliveries (i.e. overnight mail) will be adjusted as requirements are further defined.

Overhead coiling doors and secured access with a buzzer and intercom for after-hours delivery monitoring are recommended.

7. TRASH AREA

Provisions for confidential waste destruction/disposal are not required by the State of Tennessee. Methods of paper recycling need to be determined.

INTERIOR FINISHES

1. CEILING

Suspended acoustical tile ceilings and gypsum wallboard ceilings shall be placed throughout the facility except at designated mechanical rooms and service spaces where the ceiling will interfere with piping, equipment or overhead wire management. Ceiling height in general office areas shall be a minimum of 10'-0" above finished floor with a 10'-6" height preferred. Higher ceilings may be appropriate at lobby if required by design. Computer rooms shall also have minimum 10'-0" ceilings over top of raised access floor elevations due to the possible presence of tape storage silos.

The ceilings tiles selected for offices shall be standard commercial office quality. Computer Room tiles shall incorporate a vapor retardant finish, flake resistant core and incorporate a high NRC rating

2. LIGHTING

Lighting levels must be consistent with energy conservation and State of Tennessee requirements. Lighting design must consider both the quality of the work environment and the task that is to be performed. Due to the current trend toward PC usage at every workstation, indirect lighting is recommended to reduce screen glare within office areas. Special lighting features should be limited to lobby, conference rooms, break rooms, and other more public spaces.

3. WALLS AND FINISHES

In general, for reasons of economy, most walls shall be painted gypsum drywall, although a washable vinyl fabric wall covering may be considered for high traffic areas. The data center / raised floor walls should also be finished with a vapor retardant finish.

Room for trash storage and janitor closets must be spray-glazed for cleanliness and elimination of odors. Masonry shall be used in accordance with State of Tennessee Requirements and in heavy abuse areas.

4. DOORS AND HARDWARE

All access doors for computer areas shall be 42 inches clear width or 72 inch double doors (two minimum). Door heights, materials and styles shall be in accordance with State of Tennessee facility standards. Internal secured spaces will require the coordination of magnetic locks for card key access. Particular attention shall be placed on resolving conflicts between security goals and life safety / egress requirements.

5. ACOUSTICS

The project design must consider all aspects of the building (exterior, interior, mechanical, electrical, structural) in efforts to control noise.

Use STC (Sound Transmission Class) ratings not less than:

General office space, computer room 40

Executive offices	45
Conference rooms	50

Make special provision to avoid noise transmission through ductwork from mechanical equipment. Special vibration isolation measures shall be implemented for floor mounted equipment susceptible to transmitting structure borne, low frequency rumble. (e.g. UPS).

6. Floor Finishes

Generally, carpet should be used throughout except at service spaces, computer raised floor and food service areas. Proper sealers must be used in service areas and on concrete slab/floor under the raised floor area to prevent dusting. Vinyl composition tile is recommended for those areas not covered by carpet, raised floor, or sealed concrete.

Furnishings

1. Furniture

Furniture for the new data facility is anticipated to be provided in accordance with State of Tennessee standards for both offices and open workstations. The scope of work covered by this design criteria document and State of Tennessee Requirements has excluded office furniture from the building costs and has assumed this to be part of a separate budget for fixtures, furnishings and equipment.

2. Signs

The need for an interior signage system for direction and identification has not been discussed with State of Tennessee. Generally, directional signage is not required since only authorized employees are staffing and using the facility. Also, identification signage is usually not desirable in order to minimize the public awareness of the location of the critical data center operations. There may be a safety need for identification signage at equipment spaces such as battery rooms and generator rooms. Building Evacuation signage should be provided as required by State of Tennessee Standards or local codes

3. Art and Graphics

The use of artwork to enhance the office areas and public spaces was not identified by State of Tennessee and is assumed to be not within the scope of the contract.

4. Auxiliary Equipment

Provisions for orderly location and installation of auxiliary equipment items including fire extinguishers, legal boards, bulletin boards, fire hose cabinets, drinking fountains, lighting switches, receptacles, fire alarms, thermostats, etc. shall be made. These are to be coordinated with the module and partition system.

PLUMBING

1. WATER SERVICE

Domestic and fire protection system water will be provided from the water utility system from a nearby water main. A second water main supply should be identified to provide the redundancy for the critical cooling tower water makeup system for the data center cooling. Alternatively a water storage tank should be utilized for this purpose.

2. DOMESTIC WATER

The domestic water supply will provide for cold and hot water distribution to the facility. Copper pipe shall be used throughout. The water supply will be protected by a reduced pressure backflow preventer. Hot water shall be supplied by electric hot water heaters provided at or near the restrooms. The Standard Building Code Plumbing code and local codes will be the basis for the design and installation.

3. SANITARY SEWER

Sanitary sewers will connect to the city utility system. Sewer connections will be sized per codes for all fixtures. Systems will be designed and installed per the International Building Code Plumbing and City of Nashville local plumbing codes.

4. STORM SEWERS

Roof drains shall collect and drain by exterior gravity rain leaders to the sides of the building and not through the machine room space. The leaders will connect to an underground storm water system for flow to the city storm water system (if available) and/or storm water detention areas. A storm water detention system designed to State of Tennessee and local codes will be required.

5. NATURAL GAS

Natural gas service will be from the local utility gas mains and reduced in pressure from the city system with a service pressure regulator and utility meter, if gas is required for boiler or space heating needs. (Electric heating is planned for the office area air side by VAV cooling / heating system)

6. FIRE PROTECTION

The overall building will be fully sprinklered with a wet pipe system for ordinary hazard and in compliance with local codes and the NFPA standards.

The computer equipment raised floor sprinklers will be designed and installed as a double interlocked, pre-action (dry pipe) sprinkler system per the NFPA and local codes.

An FM 200 (or equivalent gas) gaseous flooding suppression will be planned for the under floor area in the main machine room.

A combination of ceiling and under-floor smoke detectors in the machine room and other IT equipment raised floor areas throughout the building will comprise the primary fire detection system. The machine room will also utilize an early warning smoke detection system (VESDA) to alert of an early incident, but not operate the suppression system. The same detection system will operate with the pre-action system and with the gaseous suppression below the computer room raised floor.

MECHANICAL

1. MECHANICAL COOLING SYSTEMS

The following mechanical design narrative outlines a design which is based on the following preliminary estimated cooling loads:

- Initial load in the computer machine room (15,000 SF) (@ 60w/sf) – 256 tons
- Expansion (future) load based on 15,000 SF (@ 120 w/sf)- 512 tons
- Rest of building (offices, core area, equipment rooms) – 45 tons

The future expansion load is anticipated to not be installed initially, but space is provided for the future equipment (chiller, cooling tower and pumps) and connections to cross connect to the Day 1 initial systems and are suggested to be included in the initial installation.

2. CHILLERS, COOLING TOWERS AND PUMPS

Provide for an initial two (2) centrifugal water cooled chillers at a nominal capacity of 320 tons plus space and piping provisions for one future identical unit. One unit will be redundant and each alone will be capable of handling the full load up to the initial distributed load level of 60 w/sf. The third (future) unit will be added to maintain the redundancy when any additional load is added through the potential building expansion of the machine room. Piping connections and housekeeping pads will be installed initially to provide for the future installation with minimal disruption.

Matching cooling towers likewise will be installed initially with space and piping hookups for a third cooling tower after the machine room expansion. The towers will be piped and valved to allow any one tower to serve any one chiller. Cooling towers will utilize VFDs to reduce energy costs.

Primary chilled water pumps and condenser water pumps will also be provided to match the chiller and cooling tower combination for an initial N + 1 redundancy level with the provision for a set of third pumps for the future chiller and tower. Three secondary chilled water pumps will be provided for two feeds to two data center chilled water loops and a third secondary pump for the remainder building loop. Primary loop pumps shall also utilize VFD for energy considerations.

3. COMPUTER ROOM AIR CONDITIONING (CRAC) UNITS

Chilled water CRAC units will be provided for the distributed cooling in the computer machine room; other raised floor areas and redundant CRAC units in the UPS rooms. The computer machine room is anticipated to require an initial fourteen (14) units including redundancy based on a unit's usable sensible capacity of approximately 24 tons. Piping connections should be provided for the future installation of an additional 12 (12) future units in the computer machine room growth area. CRAC units (redundant) are also planned for the UPS rooms and smaller capacity floor mounted CRAC units or ceiling installed CRAC units are planned for the other critical non-computer machine raised floor areas including the Printer room or Command Center and similar raised floor areas.

4. AIR HANDLING UNITS

Air handling units will be provided for the conditioned fresh air makeup to all raised floor areas and for the office and core area space cooling and heating requirements. The raised floor areas will use a dedicated fixed volume fresh air makeup unit with air ducted to the area adjacent to the CRAC units return plenums. Two variable air volume (VAV) units with chilled water cooling coils and electric reheat VAV boxes will supply ducted air conditioning to the office areas.

Air handling and ventilation units are also to be provided for the electrical equipment rooms. The loading dock will use building air and include unit heaters for winter operation when required.

5. SECONDARY CHILLED WATER PIPING LOOP

A chilled water piping loop will be designed to provide increased redundancy through a secondary chilled water piping distribution system to the critical CRAC units in the raised floor areas. The loop will comprise two loops and include a multi directional supply and return with cross connection between the two loops to allow maximum chilled water redundancy to the machine room CRACs. Pipe will be run under the raised floor in "trenches' to reduce the effect of any leakage, and to keep the pipe out of the air flow discharge air stream from the CRACs.

6. REDUNDANT WATER SUPPLY

The city water makeup supply to the building should provide for a dual path of water to the facility from a different street if available and depending on the chosen site location. The purpose is to ensure the cooling towers have a continuous supply of makeup water and that the domestic water for consumption has some redundancy, in case of a broken water line in the street. An alternative is to provide for a storage tank of domestic water for the critical purposes. If a tank is used, the size should be to accommodate the critical water needs based on the evaporation rate during a peak design day.

7. HVAC CONTROL SYSTEM

The system shall consist of a direct digital control (DDC) system which is further integrated into an overall building management system (BMS). A dedicated data center monitoring system will also be planned for the primary data center critical power and cooling equipment with a “tie-in” to the BMS.

ELECTRICAL

1. ELECTRICAL SERVICE AND TRANSFORMERS

The building data center electrical load is based on an ultimate load of 120 watts per square foot (w/sf) in the computer machine room. The initial computer machine room raised floor area is 15,000 square feet (SF). The ultimate capacity required for the computer machine room IT equipment power, the cooling for the computer machine room, and the remaining building functions including the office area is approximately 1,800 KW. However, the initial load can be sized at 60 w/sf for the 15,000 SF “computer machine room. Electrical utility service to the site should be two 4,000 amp, 480 volt feeders from two separate transformers. Although two separate electrical utility services are recommended, if a single utility service is provided, each transformer should have a utility disconnect switch so that a single building transformer can be utilized, when maintenance is being performed on the other transformer. The two utility transformers will be the beginning of the separate “A” and “B” electrical systems for the data center.

2. MAIN BUILDING PANEL

There will be two main building 4000 amp, 480 volt panels. Each panel should contain a tie circuit breaker to the other panel, so that it can be totally isolated for maintenance needs. Each panel should have a main utility circuit breaker and an interlocked circuit breaker feed from the parallel generator panel. These two circuit breakers will act as the automatic transfer switch. Open transition switching is permissible. These two panels will continue the “A” and “B” electrical systems for the data center.

3. BACKUP GENERATORS

Multiple 2000 KW diesel generators should be installed in an N+1 configuration (N+2 with a single utility feed) to provide redundancy to the utility service. The final generator load will be approximately 5,500 KW. The generators must be connected to a parallel switchgear system. The system must have provisions to add future generators when the power density of 120 w/sf is evident. The output from the parallel switchgear should provide open transition power to each of the two main building switchboards and to a third circuit breaker where a load bank can be connected to allow for testing of each generator at full load. 96 hours of backup fuel is recommended for the generators.

4. UNINTERRUPTIBLE POWER SYSTEM (UPS) AND DISTRIBUTION

Initially three 500 KVA, 450 KW, 480 volt UPS module should be installed at each main switchboard. This will provide the 60 w/sf capacity at 15,000 SF “of computer machine room space at an N+1 redundancy level. UPS System A will be redundant to UPS System B. The UPS system will have the capability to connect two additional UPS modules on each main switchboard to increase the capacity to 120 w/sf at 15,000 sf. There should always be an N+1 parallel redundant configuration. There should be a separate and distinct UPS maintenance bypass installed to allow for the removal of the UPS system, if needed, and still power the load from the utility / backup generator system is desired.

Each UPS system should have a dedicated output bus. Each panel should contain a tie circuit breaker to the other panel, so that it can be totally isolated for maintenance needs. Power Distribution Units (PDUs) should be connected to the respective UPS system. The “A” PDUs will be connected to UPS A and the “B” PDUs will be connected to UPS B. This system will allow the two-corded IT equipment to be connected to both the “A” and “B” UPS electrical systems. Single corded IT equipment should be powered from a static switch device, which will be fed from both the “A” and “B” UPS electrical systems. PDUs sized at 150 KVA or 225 KVA with four (4) 42 circuit breaker panels and the capability to connect Remote Distribution Cabinets (RDCs) should be considered, depending upon the final configuration of IT equipment to be installed.

5. Mechanical Systems Electrical Power

There shall be both, “A” and “B”, mechanical panel boards. Also, install a “C” mechanical power board, connected to an automatic transfer switch (ATS), which will be fed from both the “A” and “B” main building panels. The three mechanical panels will provide for N+1 mechanical system redundancy. This electrical system arrangement will allow for maintenance to be done on any one of the three mechanical panel boards and still allow for the mechanical systems to function in a non-redundant manner.

3. SPACE PROGRAM

DATA CENTER BUILDING 1 - SPACE PROGRAM

Area	People Capacity Bldg. 1	Net SF Feet	Required Bldg. 1 SF	Comments
Raised Floor				
Server Area	N/A	7,000	7,000	Production, Test, Growth
Main Frame	N/A	1,000	1,000	Production
Tape	N/A	1,000	1,000	Mainframe and servers
Tape Racks	N/A	1,000	1,000	Environment, Security, Fire Required
Print	N/A	2,000	2,000	Separate secure room
Telecom	N/A	2,000	2,000	Separate secure room
Development Lab	N/A	1,000	1,000	Separate secure room
	0		**15,000**	**Total Raised Floor**
Office Area				
Director	1	260	260	Office
Data Processing Network and LAN	3	64	192	Cubicles
Distributed Computing – Agency Support	1	150	150	Office - Manager
Distributed Computing – Agency Support	8	64	512	Cubicles – Support Personnel
Distributed Computing - Enterprise Support	1	150	150	Office – Manager
Distributed Computing - Enterprise Support	9	64	576	Cubicles – Support Personnel
Output Distribution / Mainframe Computing	1	250	250	Office – Assistant Director
Output Distribution / Mainframe Computing	2	150	300	Office – Manager
Output Distribution / Mainframe Computing	11	64	704	Cubicles – Support Personnel
Print Operations	6	30	0	Desks / Chairs on Raised Floor Above
	43		**3,094**	**Total Office Area**
Support Space				
Lobby	N/A	400	400	Front Entry
Loading Dock	N/A	430	430	With Covered Exterior Dock
Break Room	N/A	400	400	Sink, Refrigerator, Microwave
Housekeeping Space	N/A	100	100	Mop Sink and
Toilet Rooms	N/A	250	500	Two
Locker Room	N/A	200	200	Lockers Only
Staging and Storage	N/A	1,165	1,165	For IT Use
Situation Room	N/A	800	800	For Normal and Disaster Use.
Conference Room	N/A	320	320	One
Break Out Room	N/A	100	200	Two
Security	2	N/A	200	Security Control Area
Maintenance Support	2	N/A	200	Shop, Parts, Equipment
	4		**4,915**	**Total Office Area**
Utility Spaces				
Electrical Rooms	N/A	4,000	4,000	Switchgear, UPS, Batteries
Mechanical Equipment	N/A	3,000	3,200	Chillers, Pumps, Sprinkler
Emergency Generators	N/A	N/A	N/A	Outside
Cooling Towers	N/A	N/A	N/A	Outside
Transformers	N/A	N/A	N/A	Outside
	0		**7,200**	
Circulation of Non-Raised Floor Space			**4,976**	Walls, Aisles, etc.
Total Building No. 1	**47**		**35,185**	

DATA CENTER BUILDING 2 - SPACE PROGRAM

Area	People Capacity Bldg. 2	Net SF Feet	Required Bldg. 2 SF	Comments
Raised Floor				No Print and Enterprise Command Center
Server Area	N/A	7,000	7,000	Production, Test, Growth
Main Frame	N/A	1,000	1,000	Production
Tape	N/A	1,000	1,000	Mainframe and servers
Tape Racks	N/A	1,000	1,000	Environment, Security, Fire Required
Enterprise Command Center	0	2,000	2,000	Separate secure room (up to 25 people)
Telecom	N/A	2,000	2,000	Separate secure room
Development Lab	N/A	1,000	1,000	Separate room
	0		**15,000**	**Total Raised Floor**
Office Area				
Director	1	260	260	Office
Data Processing Network and LAN	3	64	192	Cubicles
Distributed Computing – Agency Support	1	150	150	Office - Manager
Distributed Computing – Agency Support	8	64	512	Cubicles – Support Personnel
Distributed Computing - Enterprise Support	1	150	150	Office – Manager
Distributed Computing - Enterprise Support	9	64	576	Cubicles – Support Personnel
Output Distribution / Mainframe Computing	1	250	250	Office – Assistant Director
Output Distribution / Mainframe Computing	2	150	300	Office – Manager
Output Distribution / Mainframe Computing	11	64	704	Cubicles – Support Personnel
	43		**3,094**	**Total Office Area**
Support Space				
Lobby	N/A	400	400	Front Entry
Loading Dock	N/A	430	430	With Covered Exterior Dock
Break Room	N/A	400	400	Sink, Refrigerator, Microwave
Housekeeping Space	N/A	100	100	Mop Sink and
Toilet Rooms	N/A	250	500	Two
Locker Room	N/A	200	200	Lockers Only
Storage and Staging	N/A	1,165	1,165	For IT Use
Situation Room	N/A	800	800	For Normal and Disaster Use.
Conference Room	N/A	320	320	One
Break Out Room	N/A	100	200	Two
Security	2	N/A	200	Security Control Area
Maintenance Support	2	N/A	200	Shop, Parts, Equipment
	4		**4,915**	**Total Office Area**
Utility Spaces				
Electrical Rooms	N/A	4,000	4,000	Switchgear, UPS, Batteries
Mechanical Equipment	N/A	3,000	3,200	Chillers, Pumps, Sprinkler
Emergency Generators	N/A	N/A	N/A	Outside
Cooling Towers	N/A	N/A	N/A	Outside
Transformers	N/A	N/A	N/A	Outside
	0		**7,200**	
Circulation of Non-Raised Floor Space			**4,976**	Walls, Aisles, etc.
Total Building No. 2	**47**		**35,185**	

4. Construction Budget Estimates

Summary of the Estimated Budget for a Tier III Data Center

	Total Estimated Costs For RS Gass Hilltop	Total Estimated Costs For RS Gass Masonic Home
Site Construction / Acquisition	$2,400,000 to $3,000,000	$270,000 to $320,000
General Building Construction	$2,000,000 to $2,400,000	$2,000,000 to $2,400,000
Fire Protection	$570,000 to $700,000	$570,000 to $700,000
Mechanical	$2,750,000 to $3,350,000	$2,750,000 to $3,350,000
Electrical	$5,750,000 to $6,850,000	$5,750,000 to $6,850,000
Cabling Infrastructure	$1,200,000 to $1,400,000	$1,200,000 to $1,400,000
Enterprise Command Center	N/A	N/A
Sub-Total Building Construction	**$14,670,000 to $17,700,000**	**$12,540,000 to $15,020,000**
General Conditions (15%)	$2,200,500 to $2,655,000	$1,881,000 to $2,253,000
Design (7%)	$1,026,900 to $1,239,000	$877,800 to $1,051,400
Construction Management (7%)	$1,026,900 to $1,239,000	$877,800 to $1,051,400
Sub-Total	**$18,924,300 to $22,833,000**	**$16,176,600 to $19,375,800**
Project Contingency (10%)	$1,892,430 to $2,283,300	$1,617,660 to $1,937,580
Total Project Cost	**$20,816,730 to $25,116,300**	**$17,794,260 to $21,313,380**

	Total Estimated Costs For Smyrna Airport	Total Estimated Costs For TWRA Ellington
Site Construction / Acquisition	$920,000 to $960,000	$190,000 to $230,000
General Building Construction	$2,000,000 to $2,400,000	$2,000,000 to $2,400,000
Fire Protection	$570,000 to $700,000	$570,000 to $700,000
Mechanical	$2,750,000 to $3,350,000	$2,750,000 to $3,350,000
Electrical	$5,750,000 to $6,850,000	$5,750,000 to $6,850,000
Cabling Infrastructure	$1,200,000 to $1,400,000	$1,200,000 to $1,400,000
Enterprise Command Center	$1,800,000 to $2,600,000	$1,800,000 to $2,600,000
Sub-Total Building Construction	**$14,990,000 to $18,260,000**	**$14,260,000 to $17,530,000**
General Conditions (15%)	$2,248,500 to $2,739,000	$2,139,000 to $2,629,500
Design (7%)	$1,049,3000 to $1,278,200	$998,200 to $1,227,100
Construction Management (7%)	$1,049,300 to $1,278,200	$998,200 to $1,227,100
Sub-Total	**$19,337,100 to $23,555,400**	**$18,395,400 to $22,613,700**
Project Contingency (10%)	$1,933,710 to $2,355,540	$1,839,540 to $2,261,370
Total Project Cost	**$21,270,810 to $25,910,940**	**$20,234,940 to $24,875,070**

Qualifications

1. These estimates are based on all construction being completed in 2007.
2. Additional years for construction must add the escalation costs of at least 3% to 5%.
3. This estimate is to be used for budgetary purposes only.
4. This estimate does not include any costs for site remediation.
5. The budget estimates are listed at +/- 10%.

5. CONSTRUCTION PROJECT SCHEDULE

The estimated schedule is based on the results for the preliminary statement of requirements performed for this engagement. The times are indicative of estimated time for the interior fit-up of the proposed existing or new building with associated critical facility support systems. Industry standard time frames have been reflected. The State of Tennessee will need to modify this schedule based on specific requirements. The schedule is based on work being performed in a continuous mode. Long delivery items that will affect the construction schedule include the generator, the electrical switchgear, UPS, cooling systems, raised floor tiles, and other similar items. These should be ordered during the design phase to help reduce the duration of the overall project.

The following assumptions have been made regarding the schedule.

- The Office for Information Resources (OIR) (IT Department) has accepted and approved the Statement of Requirements and has forwarded to the appropriate State Agencies.
- The State has approved the costs
- The State has established a bid with a specific end date with rewards and penalties.

Estimated Schedule (Weeks)

	Prelim Data Center Planning	Schematic Design	Design Develop-ment	Construc-tion Drawings	Bidding and Awards	Permits	Build	Commis-sioning	Total Weeks
Data Center #1	This Report	6-8	6-8	14-24	8	4	32-44	2-4	72-100
Data Center #2	This Report	6-8	6-8	14-24	8	4	32-44	2-4	72-100

Long delivery items that should be ordered early because the delivery of these items will affect the construction schedule include, but are not limited to:

- Backup generator system
- Main electrical switchgear
- Other major switchgear
- UPS system and batteries
- Chillers, cooling towers, pumps
- Raised floor tiles

6. Statement of Requirements

Executive Summary

IBM was tasked to develop a data center statement of requirements for two new State of Tennessee data centers and the requirements to update the existing data center. All three data centers will be located in or near the Nashville, TN area. The format used in this document indicates the recommendations for the architectural, fire protection, mechanical, electrical, security, and environmental equipment monitoring areas. The information in the statement of requirements has been developed by listing specific recommendations based on interviews and meetings with the staff at The State of Tennessee. IBM has gained a general consensus of the recommendations contained within this report for the design of the new / updated State of Tennessee data centers.

The following information details the IBM recommendations for the physical data center facility design specifications for the design of a data center facility for a Tier III as defined by an industry User group, The Uptime Institute. A Tier II level provides on a single active N + 1 environment. A Tier III level reduces the single points of failure and will provide The State of Tennessee with an N + 1 environment and both an active and passive path for the critical electrical and mechanical infrastructure components. (A Tier IV is the Best Practice level.) The Tiers are defined further in Appendix A in the back of this document.

In Appendix B of this document are two charts. Each chart contains the space program for each of the new data center buildings. Building 1 is located approximately five (5) miles away from the existing data center and is approximately 35,000 sf in size and will have the print operations. Building 2 is located approximately twenty-five (25) miles away from the tower and is approximately 35,000 sf in size and will have the command center. Building 2 will be the first data center building to be constructed.

IBM recommends that the State of Tennessee have two (2) enterprise command centers. One data center should be located in one of the new data center buildings. The existing command center in the tower should be upgraded to match the Tier III level of the proposed data center or the State can accept the risk of a lower tier level.

The sizes for the building and the raised floor areas have taken into account future IT growth, IT technology advances and changes, and software virtualization enhancements.

The data center facilities systems will be designed on a modular component basis to add electrical and mechanical modules as the data center load grows. However, the "full" facilities infrastructure capacity (bus ampacity, pipe sizes, etc.) must be initially installed.

The baseline requirements for use to identify real estate includes a scoring matrix and a comparison of the locations.

The information in this document is intended to be provided by The State of Tennessee to their architectural and engineering firms to reflect the requirements for the data center. Please note that these recommendations are IBM recommendations and the final configuration of the data center will be made by The State of Tennessee after careful consideration of these recommendations and any associated risks.

General Construction and Architectural Recommendations

Site and Building Recommendations

- Provide building frame systems that have adequate wind resistance for at least an F3 Tornado.
- The location should be chosen to minimize any susceptibility to both natural and man-made disasters, such as floods, lightning, hurricanes, tornados, seismic; airport, train, highway, utility line, gas line, or chemical proximity, etc.
- A minimum of 5 acres of land on which the data center building and support areas can be located. (The same size acreage should be assumed for both data centers.)
- Site should be secured from unauthorized vehicle traffic. The adjacent parking area should be restricted with a security entrance gate.
- A Tier III building and roof system is completely physically hardened for weather, geography, and other exposures. To this end the recommendation is to encase the "critical areas" in a shell and raise data center 10' above the 100 year flood plain and 5' above the 500 year flood plain.
- Provide structural systems that allow for the largest practical bay size that maximizes the flexibility of the building layout, and minimizes columns. The structural bay size should be minimum 28 ft. x 28 ft. Consider larger spans up to 40 ft. x 40 ft.
- The building will be slab on grade with a "depressed slab" to accommodate the data center area.
- The exterior wall construction is brick, block, and mortar.
- The site should be as level as possible to minimize the site work required.
- Provide minimal exterior windows for office area only.
- Provide and position systems that will allow horizontal expansion of the data center with relative ease.
- Provide a data center footprint that is relatively square or rectangular.
- Normal life safety requirements and ADA requirements must be smoothly integrated into the design.
- IBM recommends a minimum recommended structural floor loading criteria of 150 pounds per square foot (psf), if possible. Appropriate equipment placement should be done to allow for the facilities equipment and the IT equipment to be located in a safe manner.
- The structural slab shall be designed and built to incorporate a piping trench for the chilled water piping to the CRACs. Initial estimate is that the trench is 24" deep and 48" wide with floor drains located along the length.
- Aisles and corridors should be designed to be wider than typical office standard practices due to the need to move large pieces of equipment through the facility. Widths should be a minimum of 5 to 6 feet and preferably 6 to 8 feet where large equipment will be moved.
- The concrete floor should be cleaned and sealed prior to installation of the new raised floor system. The sealing will reduce and control the concrete dust and will control vapor migration.
- A raised access floor is recommended as a path for electrical power, cabling, and cool air distribution. (The raised access floor is detailed later in the report.)
- IBM has arranged the IT equipment in the computer room to allow for optimal workflow, efficient electrical distribution, and optimal cooling.

- Provide floor systems with a depressed slab design that will allow for piping, conduit and ductwork penetrations to be cut through with relative ease in the future.
- Allow for adequate adjacent areas to include restrooms, break areas with small tables or lounge seating, pantry areas with refrigerators, sinks, storage cabinets and hot water dispensers, and vending areas with machines that dispense snacks and beverages for employees who are working late shifts. Lockers or personal storage bins located near the break areas should be considered for employee convenience.
- Floor space for future growth of the IT computer hardware has been provided for in the sizing determination of the computer room and related functions. A summary of the breakdown is located in Appendix B.
- The remainder of the space in the building will be allotted for the offices, conference rooms, team rooms, related IT functions, a main lobby, rest rooms, a loading dock, a main electrical room, a telephone communications demark room, a shipping /receiving area, and a break area. The total building space required is approximately 35,000 sf for both building 1 and building 2.
- A walled or fenced-in courtyard should be constructed adjacent to the data center to house the generator(s) and the air conditioner condenser units. Protection above this courtyard should be provided to protect the enclosed equipment from flying debris.

Data Center Walls and Ceilings

- The perimeter walls of the data center shell are recommended to be a minimum of 2 hour fire rated construction.
- The interior walls for the data center space are recommended to be a minimum 1 hour fire rated construction that also provide thermal insulation and vapor control from the remainder of the facility. These walls must extend from the structural floor slab to the underside of the floor / roof structure above.
- Wall surfaces should be finished with a vapor retardant finish to better control the inside environmental humidity levels.
- Insure that all openings through fire rated perimeter walls are sealed with fire and smoke stop materials. Penetrations in these walls should be kept at a minimum.
- The data center is usually provided with an acoustic lay-in ceiling tile that is placed a minimum recommended height of 10’0” above the surface of the raised access floor to accommodate computer equipment such as tall server cabinets.
- Ceiling tiles in the data center should be especially manufactured for these environments and will be surfaced with vinyl, metal foil or some other type of impact and moisture resistant facing.
- The deck above the data center should include a water-proof membrane. This membrane can be located within a double-slab or as a part of a light-weight concrete roof that meets the environmental weather concerns.
- Door heights of 90” – 96” should be installed to allow for taller IT equipment or facilities equipment to be moved in / out of the room(s).

Raised Access Flooring:

- The required raised floor area is approximately 15,000 sf in size in both building 1 and building 2. The size of the raised floor areas have taken into account future IT growth, IT technology advances and changes, and software virtualization enhancements.
- A 30” high (finish floor height) bolted stringer system raised access floor system is the minimum recommended finish floor height.
- The surface of the floor panels should be high pressure plastic laminate faced in the data center. The floor panels should be concrete filled painted steel pans with minimum loading capacities of a 1,500 lb caster point load and a 500 – 800 lb rolling load.
- Standard 24” square raised floor panels should be used. Cut panels, less than 6” in width, should be avoided.
- All floor panel cutouts should be lined with vinyl trim to prevent damage to cables. Standard cutout sizes, such as 4” x 4”, 4” x 6”, etc., should be used.
- Additional pedestals should be installed, as required, near columns, at the perimeter, or under heavy equipment.
- Adjustable height pedestals shall be used with a locking feature.
- The base plate of each pedestal shall be secured to the concrete slab with pedestal adhesive.
- Extra pedestals and raised floor panels should be provided as spares and for future use.
- Coordinate with the mechanical design, the required number of perforated raised floor panels for air distribution into the room. Raised floor panels that can provide a minimum of 400 CFM per panel are recommended. (reference mechanical section)
- The raised access flooring provides both flexible wire distribution management and conditioned air distribution to the computer equipment. Computer room air conditioning (CRAC) units and power distribution units (PDUs) are dispersed among the equipment to maximize efficiency for wire whip length and air circulation.
- Provide for a hot aisle – cold aisle equipment layout to ensure effective distribution of under floor cooling air. The IBM equipment floor layout plan implements this concept.
- Provide for cable type water detection below the raised floor and around any floor drains.

Enterprise Command Center (ECC) – Only in Building 2

- The State of Tennessee should have two (2) command centers with one of the two being an “active” disaster recovery location that is tested and operated from on a monthly basis.
- The existing command center in the tower can be one of the ECCs with either an acceptance of risk or the appropriate upgrades to improve the reliability level to a Tier II Plus to Tier III Level.
- The ECC may be located in an area adjacent to the data center. The ECC would accommodate up to 25 personnel per shift and will require a minimum of 2,000 square feet in size depending upon workstation sharing, the type of furniture and the related monitoring technologies selected.
- Functions within the ECC should be Operations, Production Scheduling, Midrange, Distributed, Network, and Network Engineering.
- The ECC should have multiple levels of raised floor for sight line considerations and acoustics. The maximum floor depth shall be similar the data center.
- There shall not be any structural support columns or other visual impedance within the ECC.

- A dedicated Situation Room shall be next to the ECC with a view into the ECC and ECC Display Wall. This room should be a minimum of 800 sq ft addition to the ECC.
- A building conference room, which can also be used as a back up situation room or training room, should be near or adjacent to the ECC.
- Flat open single-tier operator console furniture with (2) LCD flat panel monitors per position.
- KVM (keyboard, video, mouse) technology should be employed at the operator consoles.
- Operator PC workstations should be rack mounted in a central location within the ECC space.
- Separate analog telephone lines should be installed for emergencies.
- The ECC will have a Large Screen Display Wall for monitoring system and environmental status
- The ECC will have information displays for World, National, and Local news along with multiple weather feeds, and The State of Tennessee security information.
- The ECC will utilize the same redundant electrical system as the data center.
- The ECC should have a separately controlled overhead air conditioner system, with redundancy, to provide comfort cooling for the operators.
- The ECC should be protected with a pre-action dry pipe sprinkler system. A gaseous suppression system is optional.
- The ECC will have the same or higher level security requirements as the data center.
- The ECC should have monitoring, and alert capabilities from the Data Center Environmental Monitoring System.
- Security cameras should be utilized and connected to the display systems. This will assist operators in granting access into the data center or ECC when required.
- Provisions for network printers, fax machines, and sufficient storage concealed from view of visitors.

Shipping & Receiving

- A loading dock area should be available to provide for notification of expected IT equipment delivery and subsequent transfer to the data center. Process and procedures should be prepared to provide for the immediate notification of IT equipment delivery.

Hardware Layout

- The new data center layout positions the hardware and server cabinets properly to exceed the minimum recommended service clearance of 36" between frames. Aisles are maintained to allow space for moves, adds, and changes. Future servers and network devices may require up to 48" between cabinet rows, for installation and removal. The servers and network hardware are placed to provide a 48" service clearance.
- Arrangement of the racks and hardware should provide proper orientation to the air conditioning units for good heat rejection and airflow. The layout provides hot and cold aisles. Hot aisles should not contain perforated floor panels. Most under floor activity

can take place in the hot aisles. Cold aisles should receive the perforated floor panels and supply cool air to the critical hardware and ambient space.

- Server cabinets should be installed facing front-to-front and back-to-back. Normally the backside of the cabinet is on a hot aisle.

FIRE PROTECTION SYSTEMS RECOMMENDATIONS

Fire Protection - Suppression

- Provide pre-action dry pipe sprinkler system for the data center.
- Provide a gaseous suppression system (such as FM-200, Ecaro, Inergen, etc.) as an under floor application for the data center.
- Provide a wet pipe sprinkler system for adjacent office areas and other building areas.
- Consider a gas suppression system for the critical electrical / UPS room(s).
- Install fire extinguishers with overhead signage.
- Review the recommended fire protection systems with The State of Tennessee's insurance carrier.

Smoke Detection and Fire Alarm

- Provide an early warning smoke sampling system in the computer room both under the raised access floor and on the ceiling. This should be a warning only system with no control.
- Provide smoke detectors programmed in a double verification fashion for pre-action dry pipe sprinkler system and gaseous suppression system in data center. The double verification requires at least two detectors in an alarm condition before the fire suppression cycle is initiated.
- Smoke detectors should be located under the raised floor and on the ceiling.
- Install appropriate abort buttons and manual release stations for all gaseous suppression systems. Install a telephone with a direct connection to security near all the abort stations.
- The smoke detectors should be an addressable type and can sense being dirty. They should be wired back to the fire alarm panel.
- Monitor sprinkler flow stations.
- Provide pull stations and audio/visual alarms for the building fire alarm system within the data center.
- Provide smoke / heat / flame detection in electrical and UPS equipment rooms for critical DC equipment and in the generator outside weatherproof enclosure space.
- Consider a separate mechanical exhaust system to remove smoke and / or gaseous products from the data center to the exterior to minimize any contamination in the data center.

MECHANICAL SYSTEMS RECOMMENDATIONS

Data Center and Building Air Conditioning

- IBM recommends maintaining the computer room environment at a 72^0F / 45% RH level continuously (7 x 24) operation.
- For Building 1 with a future raised floor area of 15,000 sf of computer room space for only IT equipment, and a potential initial power load density of 60 watts per square foot, 320 tons of chilled water capacity will be required including the lighter load density of the remainder of the building loads. Based on a future power load density of 120 watts per square foot, 587 tons of capacity will be required.
- For Building 2 with an IT equipment raised floor area of 15,000 sf of computer room space for only IT equipment, and a potential initial power load density of 60 watts per square foot, 320 tons of chilled water capacity will be required including the lighter loads for the remainder of the building. Based on a future power load density of 120 watts per square foot, 587 tons of capacity will be required.
- Provide a combination of down flow Computer Room Air Conditioning (CRAC) units, and ceiling installed units for the smaller raised floor areas and located throughout the raised floor spaces to provide for redundancy of cooling and air flow.
- The CRAC units, down flow or ceiling installed, should be chilled water cooled systems with humidity and reheat control in each unit.
- Provide locations of the CRAC units in the Server computer room and other raised floor areas to ensure the distributed air distribution operating redundancy to ensure adequacy of distribution of under-floor airflow throughout the room. Modularity for additional CRAC units is planned for future cooling.
- Operate all units concurrently to maintain operating redundancy.
- Design for independent floor stands, with turning vanes or scoops, for the CRAC units.
- Each CRAC unit should have an independent condensate pump to collect and pump out condensate to nearest available building waste line.
- Coordinate with the architectural design, the required number of perforated raised floor panels for air distribution into the room to distribute cooling to final equipment locations.
- Air distribution should be through perforated raised floor panels in all areas. Panels should be rated at a minimum of 25% free open area with additional panels rated at 40% to 60% free open area for higher density cooling requirements. This should be coordinated with the architectural requirements.
- Provide for an air flow simulation model of the computer equipment room to be performed initially and annually thereafter to more closely determine the correct location for the perforated floor tiles in the data centers and for the appropriate location of the CRAC units.

Air Conditioning for Enterprise Command Center (ECC), Test and Development, Telecom, Staging UPS / Battery and Equipment Rooms

- The ECC should be provided with dedicated, ceiling installed, computer room grade systems for this primary people occupied area. The units should be redundant chilled water systems with alternative piping paths to each unit to provide for overall system redundancy.
- The adjacent Situation room shall utilize the ECC cooling system. A stipulation for the situation room shall be a noise rating no greater than 30db.

- Provide dedicated installed down flow CRAC units for the Telecom and Test / Development rooms. The units are redundant chilled water systems from the secondary data center piping loop.
- The Staging / Storage area in both buildings should use the building's overhead air conditioning system for cooling and environmental control.
- The UPS / Battery rooms shall use chilled water CRAC up-flow units.(assuming a non-raised floor area) with two units (one redundant) and plans for modular future units as needed to maintain the UPS recommended operating environmental conditions. Units may be furnished without humidity or reheat control capabilities.
- The electrical and mechanical rooms should also be cooled with up-flow CRAC units to maintain reliable environmental temperatures.

Chillers, Cooling Towers and Pumps

- In Building 1, with greater loads, provide for two (2) centrifugal water cooled chillers at a nominal capacity of 320 tons each plus space and piping provisions for one future 320 ton chiller identical to the initial two units. The initial units will be redundant and each alone will be capable of handling the full load up to the initial distributed load level of 60 w/sf, for a total building load estimated at 320 tons. The third unit will be added to maintain the redundancy when additional load with potential to reach 120 w/sf (587 tons) is added through the higher power and resulting cooling loads of "blade" servers and other IT equipment. Piping connections and housekeeping pads will be installed initially to provide for the future installation with minimal disruption.

- In Building 2, provide for two (2) centrifugal water cooled chillers at a nominal capacity of 320 tons plus space and piping provisions for one future identical unit. One unit will be redundant and each alone will be capable of handling the full load up to the initial distributed load level of 60 w/sf. A third 320 ton unit will be added to maintain the redundancy when additional load with potential to reach 120 w/sf is added through the higher power and resulting cooling loads of "blade" servers and other IT equipment. Piping connections and housekeeping pads will be installed initially to provide for the future installation with minimal disruption.

- Matching cooling towers likewise will be installed initially with space and piping hookups for a third cooling tower after the machine room expansion. The towers will be piped and valved to allow any one tower to serve any one chiller. Cooling towers will utilize variable frequency drives (VFDs) to reduce energy costs.

- Primary chilled water pumps and condenser water pumps will also be provided to match the chiller and cooling tower combination for an initial N + 1 redundancy level with the provision for a set of third pumps for the future chiller and tower. Three secondary chilled water pumps will be provided for two feeds to two data center chilled water loops and a third secondary pump for the remainder building loop. Primary loop pumps shall also utilize VFD for energy considerations.

Secondary chilled water piping loop

- A chilled water piping loop will be designed to provide increased redundancy through secondary chilled water piping distribution system to the critical CRAC units in the raised floor areas. The chilled water piping will comprise two loops and include a multi directional supply and return with cross connection between the two loops to allow maximum chilled water redundancy to the machine room CRACs. Pipe will be run under the raised floor in “trenches’ to reduce the effect of any leakage, and to keep the pipe out of the air flow discharge air stream from the CRACs.

- Provide piping for city water makeup to humidifiers in each unit from the building’s city water source.
- Provide condensate water piping to drain condensate from individual CRAC units and piped to the floor drains in the piping trench.
- Provide for a cable-type of liquid detection system under the raised floor surrounding individual CRAC units and tracking along the chilled water piping and in the piping trench and along the humidifier city water lines and at other critical areas where leaks may develop. A typical leak detection system will include a display panel, which will indicate the location of the leak on the cable in feet. A graphic panel located adjacent to the panel will indicate the leak cable footage.
- Water sources over the data center should be avoided. These water sources also include roof drains. Where water sources are unavoidable, a roof / deck structure with a water-proof membrane should be considered.
- Floor drains with self priming traps should be provided in the piping trench to allow for drainage of chilled water and / or fire protection sprinkler water in the event of a discharge. A backflow valve should be used to prevent drainage from backing up onto the floor.

City Water system

- The city water makeup supply to the building should provide for a dual path of water to the facility from a different street if available. The purpose is to ensure the cooling towers have a continuous supply of makeup water and that the domestic water for consumption has some redundancy, in case of a broken water line in the street. An alternative is to provide for a storage tank of domestic water for the critical purposes. If a tank is used, the size should be to accommodate the critical water needs based on the evaporation rate during a peak design day
- A dedicated backup source from on-site water storage could be considered in case of emergency loss of water during weather catastrophic conditions for support of personnel and humidifier and cooling system usage during a utility outage.
- If a back-up source is available, use water from primary and back-up in order to maintain viability of each service.
- The back-up water system could be a well or water tank for redundancy with proper filtration.

Air Handling Units

- Air handling units will be provided to provide for the conditioned fresh air makeup to all raised floor areas and for the office and core area space cooling and heating requirements. The raised floor areas will use a fixed volume fresh air makeup unit, with a redundant unit, with air ducted to the area adjacent to the CRAC units return plenums. These systems shall meet local mechanical code and ASHRAE ventilation standards. A general guideline is for .20 cfm per square foot of raised floor area or a 20 cfm per person occupancy. This unit will serve to pressurize the data center’s raised floor space positive to the adjacent other spaces to keep out air borne contaminants and to assist in maintaining temperature and humidity. Outside air must be filtered to 99.97 % efficiency or greater. This may require HEPA (High Efficiency Particulate Air) filters that meet MIL-

STD-282. (HEPA) filters can remove more than 95 percent of most particulate matter, including particles as small as 0.10-0.20 microns.

- Recirculation air systems must be filtered to 40% atmospheric dust spot efficiency according to ASHRAE standard number 52.1.
- Two variable air volume units with chilled water cooling coils and electric reheat VAV boxes will supply ducted air conditioning to the office areas.
- Air handling and ventilation units are also to be provided for the electrical equipment rooms with the exception of the UPS / battery rooms. The loading dock will use building air and include unit heaters for winter operation when required
- Provide air handlers for cooling of the critical electrical equipment in the critical data center support systems electrical equipment room.
- Coordinate the raised floor fresh air makeup with the critical adjacent office area for IT personnel to ensure similar reliability levels.
- Evaluate and consider a separate mechanical exhaust system to remove smoke and / or gaseous fire suppression discharge and products of combustion.

Generator fuel system

- Provide for above ground diesel fuel storage tank (s), with secondary containment and leak detection and a minimum 96 hour operating capacity for continuous 96 hour operation at full load.
- Provide for future dual-piping systems connected to a duplex pumping system, to share the fuel storage capability of a future redundant generator.
- Provide sub-base type of day tank dedicated for the generator.
- Provide power for fuel system and pumps connected to emergency generator power source.

HVAC Control Systems

- The system shall consist of a direct digital control (DDC) system which is further integrated into an overall building management system (BMS).
- A dedicated raised floor computer room environmental monitoring system will furnish operating conditions to the building BMS.

ELECTRICAL SYSTEMS RECOMMENDATIONS

Redundant Electrical Service to Data Center

- The electrical load for data center can be determined from the load density of the floor space as calculated from the equipment, which is anticipated to be installed on the data center floor. The power load in the existing data center in Nashville, TN is approximately 368 KW. This translates into a current power density of 14 watts per square foot (w/sf), based on approximately 26,500 sf area of existing raised floor space or about 19 w/sf based on 20,000 sf of raised floor area that is occupied by IT equipment.
  For Building 1 with a raised floor area of 15,000 sf of computer room space for only IT equipment, and a potential future initial power load density of 60 watts per square foot, 900 KW of power will be required. Based on a power load density of 120 watts per square foot, 1,800 KW of power will be required. The load increases should be done on a modular basis of the system components. However, the initial ampacity of the various electrical buses must reflect the final build-out sizes.

  For Building 2 with a raised floor area of 15,000 sf of computer room space for only IT equipment, and a potential future initial power load density of 60 watts per square foot, 900 KW of power will be required. Based on a power load density of 120 watts per square foot, 1,800 KW of power will be required. The load increases should be done on a modular basis of the system components. However, the initial ampacity of the various electrical buses must reflect the final build-out sizes.

- A redundant electrical system with both an active and a passive path is recommended. This will meet a Tier III level. Initially IBM recommends that a redundant UPS system with multiple modules should be installed. A diesel generator system will back-up the utility service to the building. The electrical power distribution system should be designed with multiple passive bypass paths to reduce the single points of failure. The design of the electrical system should also be based on a modular approach to allow for incremental growth when required.

Power Distribution

- The building will have at least one and preferably two electrical utility feeders. With two feeders they would preferably not originate in the same utility substation nor be located in the same trench or on the same pole line.
- The utility feeders in the trench to the building should be encased in red concrete.
- Because of the possibility of severe weather, a redundant generator system should be installed to back-up the utility power to the data center. A synchronized redundant generator system is required to allow for incremental power increases with multiple generators. An N+1 generator system is required with two separate utility feeders. An N+2 back-up generator system should be installed if only a single utility supply is available. The generator system should be modular to allow for additional generators to be installed as the load increases.
- For building 1, two electrical buses of 4,000 amps each, at 480 volts, three-phase, with a full size neutral and ground each, are required. This size will support the data center, the associated mechanical equipment, and the central operations center. The final ampacity of the building electrical service should be determined during the actual design of the building, when the final tenancy requirements are known.
- For building 2, two electrical buses of 4,000 amps each, at 480 volts, three-phase, with a full size neutral and ground each, are required. This size will support the data center, the associated mechanical equipment, and the central operations center. The final

ampacity of the building electrical service should be determined during the actual design of the building, when the final tenancy requirements are known.

- Provide two separate main panel boards for the data center UPS and mechanical systems.
- All electrical panel boards should be fully fitted for future breaker needs.
- An electrical grounding system for the building should be installed. The grounding system, or signal reference ground, should be extended to the data center and include grounding of the raised floor and the telecommunications distribution board in the data center. The bolted raised floor stringers should be grounded every 10 feet in a cross-hatched pattern with a #4 AWG bare stranded copper wire.
- A Transient Voltage Surge Suppression (TVSS) should be installed on the incoming service and on the panels feeding the UPS systems and the mechanical equipment to protect the equipment from external electrical surges, from the utility, the generator, lightning, etc.
- A lightning protection system should be installed for the building and all data center related equipment located on the roof or located away from the building.
- Feed general lighting and wall mounted convenience receptacles in the data center from the building distribution system or from the mechanical distribution system.

Generator

- Since the data center consumes the majority of the electrical load (greater than 90%) for the building, utilizing a generator system to backup the entire building is recommended. Provide an outdoor weather-proof / sound attenuated enclosure for the generators. A walled or fenced-in courtyard should be constructed to house the generators (and the air conditioner condenser units). Protection above this courtyard should be provided to protect the enclosed equipment from flying debris. Provide 96 hours of diesel fuel to feed a sub-base day tank for each generator.
- Because of the possibility of severe weather, a redundant generator system should be installed to back-up the utility power to the data center. A synchronized redundant generator system is required to allow for incremental power increases with multiple generators. The generator system should be modular to allow for additional generators to be installed as the load increases. An N+1 generator system is required with two separate utility feeders. An N+2 back-up generator system should be installed if only a single utility supply is available.
- Power the data center through automatic transfer switches (ATSs), which are fed from both building utility power and the generator. A by-pass isolation feature should be included with the ATS. The ATS can be located in the main electrical room.
- An alternative is to utilize circuit breaker switching mechanism as an integral part in the main switchboard lineup.
- The ATS can be located in the main electrical room or can be an integrated part of a switchboard lineup.
- The generator system should be sized to provide power to the data center UPS, cooling, lighting, network, other critical data center operations, the remainder of the building functions. The generator system should be incrementally expandable (modularly) to power future UPS and cooling modules. The ultimate generator system size would be approximately 5,500 KW in size for building 1. The ultimate generator system size would be approximately 5,500 KW in size for building 2.

UPS/Battery

- For building 1, based on a future raised floor area of approximately 15,000 sf of computer room space for only IT equipment, and a potential future initial power load density of 60 watts per square foot, 900 KW of power will be required. Incrementally, based on a power load density of 90 watts per square foot, 1,350 KW of power will be required. For an ultimate and final power load density of 120 watts per square foot, 1,800 KW of power will be required. Provide a redundant N+1 UPS system that can be incremented with additional modules to achieve the future power capacity. Therefore, install a 480 volt input, 480 volt output UPS system for the data center. Therefore, three 500 KVA, 450 KW UPS modules can be installed in an N+1 manner with a future expansion for two more modules. The UPS should always maintain the N+1 redundancy.
- For building 2, based on a future raised floor area of approximately 15,000 sf of computer room space for only IT equipment, and a potential future initial power load density of 60 watts per square foot, 900 KW of power will be required. Incrementally, based on a power load density of 90 watts per square foot, 1,350 KW of power will be required. For an ultimate and final power load density of 120 watts per square foot, 1,800 KW of power will be required. Provide a redundant N+1 UPS system that can be incremented with additional modules to achieve the future power capacity. Therefore, install a 480 volt input, 480 volt output UPS system for the data center. Therefore, three 500 KVA, 450 KW UPS modules can be installed in an N+1 manner with a future expansion for two more modules. The UPS should always maintain the N+1 redundancy.
- A modular approach should be taken for the UPS system. The UPS system should be built for the 120 w/sf capacity. Initially the build out should be at 60 w/sf. Incremental UPS modules should be installed to increase the capacity to 90 w/sf and then finally to 120 w/sf.
- Provide a separate and distinct wrap around external maintenance bypass switch for the UPS system to allow for the UPS to be entirely removed without shutting down power to the data center.
- Provide a minimum of 10 minute battery backup time. Valve regulated sealed cell batteries rated for 10 years are recommended. Provide redundant battery cabinets for each UPS module.
- The UPS system would feed separate UPS output panels (“A” and “B”) to reduce the number of single points of failure.

IT and Mechanical Power Distribution

- Provide approximately ten (10) Power Distribution Units (PDUs) with a maximum number of 42-circuit breaker panels (3 panels). The final determined number of PDUs should be determined during the design phase. Bolt-on type of branch breakers should be utilized.
- Provide K-rated shielded isolation transformers.
- Power to server cabinets should be dual feeds from the “A” and “B” UPS output electrical systems and each feed should be to a single twist lock receptacle.
- Branch circuit whips shall be installed in water-tight flexible conduit from either “A” and “B” output buses and should be color coded per bus (blue / gray).
- Provide whips to planned loads with high quality twist-lock connectors.
- Limit duplex receptacles (so the actual connected load can be accurate and no extension cords can be improperly utilized under the raised floor).

- Install an emergency off (EPO) system in the data center for the UPS / PDUs and computer room air conditioners. The EPO should be installed at all major exits. Covers may be installed over the EPO to prevent accidental operation.
- Feed data center CRAC units from separate (multiple) power panels for redundancy and to reduce the number of single points of failure.
- The mechanical cooling electrical power panel for the CRAC units should be fed from the same electrical panel source that provides the input panel to the UPS system and is also backed up from the generator system.
- All circuit breakers and receptacles should be labeled as to their function. The corresponding panel schedule inside of the PDUs shall identify this information.
- Power strips or rack mounted power distribution units (PDUs) internal to the cabinets and racks should be installed by IT personnel. These PDUs can be purchased as an "ordinary" type of PDUs with receptacles, a PDU that has a visual ammeter that monitors the load plugged into the receptacle, or an enhanced PDU that has both a visual ammeter for monitoring the load and a network connection (Ethernet or USB) that will allow both remote monitoring of the PDU and control of power to the receptacles.
- UPS power distribution should also power the receptacles in the situation room.

Security

- Design system to meet specific state requirements.
- A badge or card system should be utilized for access into the data center spaces. The badge system should allow for layered (level) control to limit access to more secure areas.
- More critical areas require access can also utilize a biometric devise for finger prints, palm readers, iris recognition, or similar, if required by state security regulations.
- Monitor data center entrance doors for alarms.
- Monitor critical system area doors for alarms (such as the UPS room and electrical room).
- Provide cameras at all entrances and in critical areas within the data center. Record camera activity on DVR or on a server drive. Locate the camera monitors in both the command center area and in site security, if available.
- A written security plan for the data center must be established and reviewed on a regular basis.

Environmental Monitoring Systems

- Monitor alarms of mechanical systems.
- Monitor the under floor leak detection system and room ambient temperature and humidity alarms.
- Monitor electrical systems, such as the generator system, UPS, floor mounted PDUs, cabinet / rack mounted PDUs, and other electrical components.
- Utilize a dedicated data center monitoring system. Enterprise Command Center personnel, data center and IT personnel, facilities maintenance personnel, and security should all monitor the alarms.

- Automatic notification to The State of Tennessee personnel, via pagers or two-way communication devices should occur.
- Sophisticated monitoring systems, such as a Liebert Site Scan or an Eaton Forseer system are available. These systems will monitor all critical equipment, record alarm activity, and page personnel.
- The building management system (BMS) can also be used to provide this monitoring capability.
- The alarms should also be networked based so that all IT personnel can review the alarms.

COMMISSIONING AND INTEGRATED SYSTEMS TESTING

Commissioning

- To insure that each component and/or system operates properly, provide a complete commissioning plan to completely test and verify the proper operation of all electrical, mechanical, security, and monitoring components.
- Provide a detailed system operational manual that includes all information for switching and controlling all electrical and mechanical devices.
- A recommended routine maintenance manual should be provided that indicates when components should be maintained and what should be tested.
- Provide for customer training for all systems.
- Provide as-built drawings.

Integrated Systems Test

- Provide a complete integrated test plan to completely test the integrated operation (and simulated failure) of all electrical, mechanical, security, and monitoring components.
- The Integrated Systems Test is extremely important to be performed to insure that all systems operate and interact properly with each other. The UPS should be tested with both utility and generator power. Heat load in the room should be simulated with electrical load banks to test the CRAC capacities, when the UPS testing is being performed. The proper function of the generator and the ATS must be confirmed. The operation of the redundant components should be confirmed. During this period, the equipment alarms should be recoded to insure that they are functional.
- The fire system should be tested by the fire alarm contractor.

CABLING SYSTEM DESIGN CRITERIA

There are many requirements that impact the design for an enterprise class cabling plant for data centers. The following characteristics should be considered as they drive requirements to the cabling infrastructure and its design.

Reliability

- Most data centers have a 24 x 365 operations schedule. This demand for high reliability can be very dependent on the planning that is done during design phase of the project. Although reliability is an important factor in the State of Tennessee's selection of equipment, the physical infrastructure is more likely to remain in place for a longer period of time and requires at least the same attention to reliability.
- Planning is needed for the site facilities to meet the requirements for the infrastructure. This planning involves the appropriate size and quantity of cabling pathways and raised floor space. It could also include appropriate means to control the cable bend radius, slack management, and access for minimum disturbance during Move-Adds-Change activity.
- To ensure reliable connectivity, the cabling system should be selected for the environmental conditions in which they are installed. Environment conditions that can affect cabling performance include temperature, humidity, and corrosives. The physical layout of the equipment, density and the associated connectivity racks, panels and paths must also ensure that appropriate link lengths are maintained and that EFI, RFI, and radiation exposure is minimized.
- To avoid costly errors and mistakes, identifying labels and color-coding of patch panels and cables help minimize the chance of problems both during installation and follow-on Move-Add-Change activity.
- To ensure the highest reliability, the design should include the requirements for cable pathways, cabling media and performance levels, physical placement of equipment, and cabling layout.

Availability

- The demand for availability is also increasing dramatically. Availability is usually associated with the redundancy of active equipment, both externally and internally. Aspects of the design, including the physical infrastructure, need to be assessed to ensure operations meet both current and future demands. For example, more operations now have critical back-up and recovery processes that put an increased demand for availability on the physical infrastructure.

- Data centers may require only a simple point-to-point connectivity over an extended distance or they may need a robust multi-path approach, in both cases, the cable paths within and outside the data center need to be investigated. All single points of failure need to be mitigated, if not totally removed. Within the building, paths must be such to minimize disturbances once installed. It is recommended that the State of Tennessee evaluate the entrance pathways provided by the Telco providers and validate that the pathways chosen will provide the required diverse pathways into the facility.

- When connecting a data center to leased fiber, availability will require that the fiber enter the building from different directions and perhaps even from different suppliers. There will also be connections to multiple entrance facilities within the building.

- The requirements for availability within the design of the physical infrastructure include the pathway layout and sizing, as well as the types and quantities of media needed.

Serviceability

- All data centers change over time. Growth, as well as new services and equipment, will drive the State of Tennessee or their service providers to add or reconfigure the initial installation. Anticipating growth must be part of the initial physical infrastructure design. These considerations include appropriate labeling, planned cabling spares, pathway capacity, and accessibility. The entire design requires a provision for planned growth that includes patch panels, conduits, and pathways.

- Power, lighting, and service clearance around racks, frames, or cabinets must be planned. A more specific consideration in this area is adequate airflow within the data center itself and the Data Center frames, especially if additional cabling and power is required in the future.

- Serviceability is easily impacted by change, especially in the area of installation documentation. Adequate provisions must be made to update and administer the installation documents in an accurate and cost effective manner.

- The requirements for serviceability are used to adjust the layout and density of the panels, the types, routing and density of the pathways, and the HVAC considerations for the equipment.

Modular / Manageable Growth

- Underlying every other requirement is the concern and understanding of the plan for an eventual upgrade. This requires that the design be both consistent and adaptable to future growth. There should be an adherence to a standard in the types of equipment used. When applied in the context of a physical design, this includes the selection of a product set that has consistently offered multiple generations of products that using the same basic sheet metal and dimension. This ensures that a growth plan can allocate the space needed to increase capacity at a defined density. The trend in server and storage equipment has consistently been to increase capability in a smaller space. If adequate HVAC and power is to be provided, then adequate patching capability should also be considered. Installing higher performance cabling, either copper or fiber should be considered if it may be required to handle the bandwidth requirements of next generation equipment.
- The requirements for future upgrades determine the density of equipment and patching capabilities and provide input to pathway layout and sizing.

Density

- The size of the required infrastructure closely mirrors the density of the active devices, but there is also the additional consideration of cost. Different types of the equipment also have different connectivity requirements. Equipment with 16 or 24 ports in 1U is available from many manufacturers of hubs, switches, and routers. There are also patch panels proportioned to allow a one to one ratio to be maintained with the equipment. However, the port density drops with storage and server equipment.

- A design should consider the organization of the patch panels within the racks and cabinets. The symmetry of the panel layout varies according the State's requirements, the type of equipment and applications supported. For example, eight ports on the right side of a 24-port panel are designated for a particular function. This mixes the Data Center functions on each panel, but allows for higher density when many functions are supported in one rack, frame, or cabinet. Panel port density need to include provisions for growth, cable management, labeling, serviceability, reconfigurations, and aesthetics.

- Density also affects the amount of vertical space needed by the associated cables. Unless provisions are specifically made to manage capacity and air flow from the under floor plenum, the State of Tennessee's density requirements may cause an unacceptable number of cables to be located into a confined space. The density of the panels also drives the need for under floor or overhead pathways. The amount of cabling could also overload pathways to and from a rack, frame, or cabinet.

- Density requirements usually follow the equipment layout. However, adequate room for cable management and labeling impacts the way density of equipment can be achieved successfully. The density requirement determines the minimal cable count and the size of cutouts needed to gain access to under floor pathways.

- The design density needs to balance the number of server ports, the number of connectivity ports, and the number of network equipment ports. To further complicate the decision, make sure to include appropriate numbers of Keyboard-Video-Mouse (KVM) ports in the rack layout as well. As an example, consider the scenario where the design can be optimized for servers in 1, 3, 4, or 5U configurations and high-density switches with up to 288 ports per unit. Significant costs differences occur if the design is optimized for one or the other end of the spectrum and then any changes made later.

Network Protocols

- The network protocols determine the design options for cable media, panel density, and in some respects the pathway requirements. When the logical design is completed, protocols and connections between each piece of equipment are known. This information determines the type of cabling media that can be used, the quantity of media and the support structure needed to build the physical infrastructure design. Media decisions also determine maximum distances allowed between equipment, but in a single site installation, these limits may not be a factor.
- The network protocol requirements determine the distance and media allowed in the design, which then influence the practical aspects of routing, density, media selection and pathway requirements.

Cable Management

- The ability to identify specific cables is addressed by various standards, but Data Center planning activities determine the State of Tennessee's requirements for labeling, color-coding, and aesthetics. Once these have been determined, layout drawings with details can be produced and used as instructions for the installation. In addition, planning for high density needs to allow for the inclusion of horizontal and vertical cable management hardware, label mounting, and pathway routing.

- The method for documenting the design as a final installation must be addressed with the State of Tennessee. The types of labels used usually determine the tool set needed to generate the documents. EIA/TIA-606 has some specific requirements in addition to the use of a Cable Management System (CMS).
- Cable management requires a system to physically mark or label each physical cable. In addition to labeling the panel near the various connectors, the cable bundles or trunks between racks, frames, or cabinets needs to also be addressed. Cable label should be printed with the appropriate To-From information. How this information is actually produced is also part of the documentation decision and the State of Tennessee's requirements.
- Cable management requirements help determine the documentation tools, the physical space needed for management hardware and labeling, as well as plans for cable labeling.

Security

- Physical security of the facility is usually provided for in the site requirements. However, the connection of the Data Center to the service provider network does affect the pathways located and cabling link budgets. The more areas in which equipment is placed, the more attention to security must be paid to the wall penetrations and potentially link budget planning.

- All patching should be located in secure racks / cabinets or rooms. They should be properly labeled and access controlled. This minimizes the risk during reconfiguration and the potential for unintended service interruptions.

- Though this requirement appears to be of primary concern to the facilities designers, the security of the pathways and distances must be evaluated in the Data Center physical design.

Cable Separations

- Within the State of Tennessee data center, there are specific distance separations requirements between communication cables and power. It is critical for the system designer to understand these specific requirements set forth in standards.

Warranties

- It is recommended that the State of Tennessee request a cabling system supplier that provides a minimum of a fifteen (15) year System Warranty for a Structured Cabling System shall be available to cover applications and components on all passive telecommunication equipment and cable as well as labor associated with the change out of any non-performing product.

- In addition, the State of Tennessee may desire a performance guarantee warranty as well. This guarantee provided by several manufactures will ensure that the cabling plant will work as specified for current as well as known emerging technologies. Most of these warranties will cover the cost of labor and materials to replace or repair any deficiencies within the enterprise cabling system.

Cable Tray System

- The cable management system should be installed in the hot aisles. This provides easy access for removal and installation of cables.

- Cable tray installed beneath the raised floor will be supported with the floor pedestals. The use of uni-thread into the sub-floor will not be allowed since it may compromise any vapor barrier or surface treatment. Fiber Optic and Copper cables will be separated in their designated trays or using a divider.

- In addition, the cable tray system shall be designed and installed with cable separation requirements taken into account.

- Provide a cable tray system utilizing wire mesh type trays provided by GS Metals or Cabolfil or approved equal. Unclassified cables will be routed though under floor cable trays and classified in a separate under floor cable tray.

Grounding and Bonding

- A common connection should be established in each building between the power neutral and the main building ground electrode. This ground conductor, a minimum 6 AWG should be attached to a copper ground bar in each Telecommunication Room. The bar should be of sufficient size to permit other connections to be made ranging from 6 AWG to 14 AWG Conductors. All conduits are to be bonded together and bonded to this ground.

- Bonding of all conduits and Communication Equipment Racks to ground will be required for the prevention of electrical shock and/or damage to equipment. Proper grounding will eliminate variations in earth ground potential and provide a safe passage for the discharge of errant high voltage that may come in contact with telecommunications cables.

- All earth bonding must be tested to national standards. Portable hand held units capable of performing these tests are commercially available. The acceptance tests and trouble-shooting are designed to ensure that the cabling components have been correctly installed and have not suffered damage during transport or installation. It is assumed that it has been verified that the correct components have been specified, delivered and installed. In such a case the following tests are sufficient:

Testing

- The responsibility for ensuring compliance of the finished project is the responsibility of the project manager. If the design uses pre-manufactured cables, the required tests may be significantly less than field connectorization because quality levels are warranted from the manufacturer. If a significant number of the cables are terminated on site, a more formal test and acceptance plan must be determined. The physical infrastructure designer needs to decide what tests are appropriate for the design and create a test plan for the project manager to execute.

- Most input for a test and acceptance plan comes from the link and performance definitions from the standards and manufacturer.

Other State of Tennessee Cabling Requirements

- Taking into account the specifications and recommendations above, design the cabling system with the following requirements.

- Design the cabling system with pre-wired fiber and copper patch between Network cabinet in computer room and Telco room.
  - Fiber patch cabinet
  - At least 48 pairs fiber terminated with SC connectors
  - At least 48 pair Category-6 with RJ45 connectors
  - At least 48 pair punch downs.
- Provide a minimum of 24 Copper Category 6 cables from each equipment rack to the Network Cabinet(s). Provide a minimum of 12 fiber strands from each cabinet to the network cabinet(s).
- Provide Individual runs to stand alone equipment within the data center. These requirements and locations will need to be determined by the State of Tennessee.
- The facility should be furnished with a minimum of two fiber optic feeders from two separate telecommunication providers. Each feed should enter the site from a different direction and should enter the building at a separate location. A (fiber) sonnet loop should be considered.
- Phone service from dual providers should be included.
- Telecommunication services should not pass through the same central office.
- Dedicated horizontal trunk cables and patch panels are recommended between the network backbone cabinets and each HW row with network connections. The required bandwidth and the number of channels determine the sizing of the trunks and panels.
- Server cabinets must be placed on the floor to comply with cable length restrictions (i.e., SCSI cables). SCSI cables are usually a maximum length of (20) meters. Future servers with a fiber interface may be installed for longer distances between interconnecting devices.
- The network hardware cabinets are aligned in a parallel direction in a central location of the data center. Network hardware must remain within the TIA/EIA 568 standards for horizontal channels. Future network and server frames are shown on the layout drawing.

Data Center Classifications

Uptime Institute Tier Classification

IBM has included the following information for reference purposes which was obtained from the White Paper on The Uptime Institute web site: http://www.upsite.com. This is presented to illustrate a view of data center reliability / availability.

Tier 1 Data Center –
Typically Delivers 99.671% Availability (Basic)

A Tier 1 data center is susceptible to disruptions from both planned and unplanned activity. It has computer power distribution and cooling, but it may or may not have a raised floor, a UPS, or an engine generator. If it does have a UPS or generators, they are single-module systems and have many single points of failure. The infrastructure should be completely shut down on an annual basis to perform preventative maintenance and repair work. Urgent situations may require more frequent shutdowns. Operation errors or spontaneous failures of site infrastructure components will cause a data center disruption.

Tier II Data Center –
Typically Delivers 99.749% Availability (Redundant Components)

Tier II facilities with redundant components are slightly less susceptible to disruptions from both planned and unplanned activity than a basic data center. They have a raised floor, UPS, and engine generators, but their capacity design is “Need plus One” (N+1), which has a single-threaded distribution path throughout. Maintenance of the critical power path and other parts of the site infrastructure will require a processing shutdown.

Tier III Data Center –
Typically Delivers 99.982% Availability (Concurrently Maintainable)

Tier III level capability allows for any planned site infrastructure activity without disrupting the computer hardware operation in any way. Planned activities include preventative and programmable maintenance, repair and replacement of components, addition or removal of capacity components, testing of components and systems, and more. For large sites using chilled water, this means two independent sets of pipes. Sufficient capacity and distribution must be available to simultaneously carry the load on one path while performing maintenance or testing on the other path. Unplanned activities such as errors in operation or spontaneous failures of facility infrastructure components will still cause a data center disruption. Tier III sites are often designed to be upgraded to Tier IV when the client’s business case justifies the cost of additional protection.

Tier IV Data Center – Typically Delivers 99.995% Availability (Fault-Tolerant)

Tier IV provide site infrastructure capacity and capability to permit any planned activity without disruption to the critical load. Fault-tolerant functionality also provides the ability of the site infrastructure to sustain at least one worst-case unplanned failure or event with no critical load impact. This requires simultaneously active distribution paths, typically in a System + System configuration. Electrically, this means two separate UPS systems in which each system has N+1 redundancy. Because of fire and electrical safety codes, there will still be downtime exposure due to fire alarms or people initiating an Emergency Power Off (EPO). Tier IV requires all computer hardware to have dual power inputs as defined by the Institute's Fault Tolerant Power Compliance Specification Version 1.2 (www.uptimeinstitute.org/spec.html). Tier IV site infrastructures are the most compatible with high availability IT concepts that employ CPU clustering, RAID, DASD, and redundant communications to achieve reliability, availability, and serviceability.

	Tier I	Tier II	Tier III	Tier IV
Number of delivery paths	Only 1	Only 1	1 active, 1 passive	2 active
Redundant Components	N	N+1	N+1	2 (N+1) or S+S
Support Space to Raised-Floor Ratio	20%	30%	80-90%	100%
Initial watts/square foot	2-30	40-50	40-60	50-80
Ultimate watts/square foot	20-30	40-50	100-150	150+
Raised Floor Height	12"	18"	30" – 36"	30" – 36"
Floor Loading - psf	85	100	150	150+
Utility Voltage	208,480	208,480	12-15 KV	12-15 KV
Months to Implement	3	3-6	15-20	15-20
Year First Deployed	1965	1970	1985	1995
Construction $/Raised Floor Square Footage*	$450	$600	$900	$1,100+
IT Site Downtime/YR	28.8 hours	22.0 hours	1.6 hours	0.4 hours
Availability	99.671%	99.749%	99.982%	99.995%

* *Excludes land and abnormal civil costs. Assumes a minimum of 15,000 SF "of raised floor, architecturally plain one story fitted out with initial capacity, but with the backbone designed to reach the ultimate capacity with the installation of additional components. Make adjustments for New York City, Chicago, and other high cost areas.*

IBM acknowledges that this information was obtained through the public domain.

7. Site Evaluations

Summary

As part of the Phase 3 portion of the contract for Facilities Infrastructure Design Planning, the IBM team of Tom Nadolny, John Bergacs, IBM's subcontractor Brian Tune, of Tune Design, and Tim Herman and Nick DePalma, of the State of Tennessee, visited and reviewed seven sites on November 14 and 15, 2006. This summary report presents the ratings for all seven sites, reflecting the factors evaluated and an update to the original ratings.

Based on un-weighted scoring, the table below reflects the scoring that was given by IBM to each of the seven sites. The table also lists the significant advantages and the significant disadvantages of each of the seven sites. Only one site, the State RS Gass Masonic Home site was considered to be significantly above average. The State-owned TWRA Ellington Agricultural Center, the Smyrna Jones property Regional Airport location and the RS Gass hilltop location sites were considered to be above average. The Ashland City Highway on the northwest side of Nashville was average. The remaining two sites in Antioch, Bell Road and Rural Hill Road were considered to be below average.

Site Comparison

Site	Score	Advantages	Disadvantages
TWRA Ellington Agricultural Center	62	*State owned location *Electrical Power and Fiber / Copper on site *Away from Man-made Hazards	*Topography – soil movement required - high cost for site improvements. No roadway nearby. *Must be constructed above "adjacent flood plain" *Not fully 10' above 100 yr flood plain
1572 Bell Road, Antioch	27	*Multiple Fiber-Copper Available	*Property long and narrow *Stream near front end of property *High site development costs *Along multilane road *Gas station and convenience store adjacent *50% of property is flood plain requiring a "No Rise Certification"
1421 Rural Hill Road, Antioch	25		*Pond on Property *RM 20 Zoning *Front of property is road drainage area-sloping topography *Anticipated high site development and acquisition costs *Near major shopping mall *Road work needed for entrance
Smyrna, Jones Property, near Regional Airport	64	*Electrical Utility Adjacent *Multiple Fiber-Copper Available *Large, flat property	*Airport flight path *Currently listed for multi-family zoning. Will require rezoning or variance. *Expensive site acquisition but low site development costs

RS Gass Blvd. Hilltop Location	63	*State owned location *Electrical Power and Fiber / Copper on site	*Topography – soil movement required –The site is a hill and slopes 30' over 100' (33%) *Site development costs are high. *TBI, railroad, and interstate highway adjacent *State communications tower adjacent
RS Gass Blvd. Masonic Home Location	70	*State owned location *Electrical Power and Fiber / Copper on site	*Topography relatively flat site and site development costs will be low. *TBI, railroad, and interstate highway adjacent *State communications tower is further removed than the Hilltop location
4433 Ashland City Highway	53	*Multiple Fiber-Copper Available	*Prison, railroad, and interstate highway adjacent *Sanitary Sewer Easement needed reducing available usable acreage
2955 Brick Church Pike	No Review		Adjacent to an Interstate Highway

Based on our findings, IBM feels that two State of Tennessee owned site, RS Gass – Masonic Home location and the TWRA Ellington Agricultural Center, and the Smyrna Jones Property Regional Airport location should be pursued to construct the two data centers. Three sites are listed so that one site can serve as a backup location, should one of the first two choices develops a problem. Therefore, the choice of one of the state sites as a backup might be the right methodology to use since there is not a worry of having to acquire an already state owned property in the future.

As in all cases, none of the sites reviewed is absolutely a perfect site. IBM has found that finding a perfect site is extremely difficult. In addition, what may be considered to be a perfect site today will not be as perfect in the future as growth and progress of the city, county, town, etc. changes as time passes.

Following this are the scoring results from the seven sites that were reviewed.

SITE SELECTION SCORING MATRIX

Site Name and Location: TWRA Ellington Agricultural Center, Hogan Road, Nashville, TN 37220

Factor or Consideration	Weight Factor High Medium Low	Top Ranking Qualitative Assessment of Findings 10	Above Average 9	8	7	6	Average (Mid-level ranking) Assessment of Findings 5	Below Average 4	3	2	1	Lowest Ranking Qualitative Assessment of Findings 0	Comments
Electric Utility Service	H		9										Power Description from Alternative Site Selection Summary
Fiber – Copper Availability	H		9										Communications Infrastructure Availability
Planning / Zoning (state / local incentives)	M	10											Present Zoning Conditions / Variances required
Site Environmental Requirements	H	10											Environmental Study Required?
Useable Gross Acres Available, Topography	M			8									Five (5) acres minimum
Natural Hazards (Flooding, Hazardous Weather, Seismic)	M									2			Information from Site Selection Summary document
Man-Made Hazards (highways, rail, airport)	M			8									From Site Selection Summary document
Cost of Site	L					6							Market valuation / site development
Scoring Total	**62**												

Un-Weighted Score - State of the Art 69-80, Above Average 54-68, Average 40-53, Below Average 0-39

Site Name and Location: 1572 Bell Road, Antioch, TN 37013

Factor or Consideration	Weight Factor High Medium Low	Top Ranking Qualitative Assessment of Findings 10	Above Average				Average (Mid-level ranking) Assessment of Findings 5	Below Average				Lowest Ranking Qualitative Assessment of Findings 0	Comments
			9	8	7	6		4	3	2	1		
Electric Utility Service	H					6							Power Description from Alternative Site Selection Summary
Fiber – Copper Availability	H			8									Communications Infrastructure Availability
Planning / Zoning (state / local incentives)	M									2			Present Zoning Conditions / Variances required
Site Environmental Requirements	H									2			Environmental Study Required?
Useable Gross Acres Available, Topography	M									2			Five (5) acres minimum
Natural Hazards (Flooding, Hazardous Weather, Seismic)	M									2			Information from Site Selection Summary document
Man-Made Hazards (highways, rail, airport)	M								3				From Site Selection Summary document
Cost of Site	L									2			Market valuation / site development
Scoring Total	**27**												

Un-Weighted Score - State of the Art 69-80, Above Average 54-68, Average 40-53, Below Average 0-39

Site Name and Location: 1421 Rural Hill Road, Antioch, TN 37013

Factor or Consideration	Weight Factor High Medium Low	Top Ranking Qualitative Assessment of Findings 10	Above Average 9	8	7	6	Average (Mid-level ranking) Assessment of Findings 5	Below Average 4	3	2	1	Lowest Ranking Qualitative Assessment of Findings 0	Comments
Electric Utility Service	H						5						Power Description from Alternative Site Selection Summary
Fiber – Copper Availability	H						5						Communications Infrastructure Availability
Planning / Zoning (state / local incentives)	M								3				Present Zoning Conditions / Variances required
Site Environmental Requirements	H							4					Environmental Study Required?
Useable Gross Acres Available, Topography	M									2			Five (5) acres minimum
Natural Hazards (Flooding, Hazardous Weather, Seismic)	M								3				Information from Site Selection Summary document
Man-Made Hazards (highways, rail, airport)	M								3				From Site Selection Summary document
Cost of Site	L									2			Market valuation / site development
Scoring Total	**27**												

Un-Weighted Score - State of the Art 69-80, Above Average 54-68, Average 40-53, Below Average 0-39

Site Name and Location: Jones Property, Smyrna, TN 37167

Factor or Consideration	Weight Factor High Medium Low	Top Ranking Qualitative Assessment of Findings 10	Above Average 9	8	7	6	Average (Mid-level ranking) Assessment of Findings 5	Below Average 4	3	2	1	Lowest Ranking Qualitative Assessment of Findings 0	Comments
Electric Utility Service	H				7								Power Description from Alternative Site Selection Summary
Fiber – Copper Availability	H		9										Communications Infrastructure Availability
Planning / Zoning (state / local incentives)	M			8									Present Zoning Conditions / Variances required
Site Environmental Requirements	H		9										Environmental Study Required?
Useable Gross Acres Available, Topography	M	10											Five (5) acres minimum
Natural Hazards (Flooding, Hazardous Weather, Seismic)	M			8									Information from Site Selection Summary document
Man-Made Hazards (highways, rail, airport)	M					6							From Site Selection Summary document
Cost of Site	L				7								Market valuation / site development
Scoring Total	**64**												

Un-Weighted Score - State of the Art 69-80, Above Average 54-68, Average 40-53, Below Average 0-39

Site Name and Location: Hilltop Location at 901 RS Gass Blvd., Nashville, TN 37216

Factor or Consideration	Weight Factor High Medium Low	Top Ranking Qualitative Assessment of Findings 10	Above Average 9	8	7	6	Average (Mid-level ranking) Assessment of Findings 5	Below Average 4	3	2	1	Lowest Ranking Qualitative Assessment of Findings 0	Comments
Electric Utility Service	H	10											Power Description from Alternative Site Selection Summary
Fiber – Copper Availability	H		9										Communications Infrastructure Availability
Planning / Zoning (state / local incentives)	M	10											Present Zoning Conditions / Variances required
Site Environmental Requirements	H	10											Environmental Study Required?
Useable Gross Acres Available, Topography	M				7								Five (5) acres minimum
Natural Hazards (Flooding, Hazardous Weather, Seismic)	M			8									Information from Site Selection Summary document
Man-Made Hazards (highways, rail, airport)	M					6							From Site Selection Summary document
Cost of Site	L								3				Market valuation / site development
Scoring Total	**63**												

Un-Weighted Score - State of the Art 69-80, Above Average 54-68, Average 40-53, Below Average 0-39

Site Name and Location: Masonic Home Location at 901 RS Gass Blvd., Nashville, TN 37216

Factor or Consideration	Weight Factor High Medium Low	Top Ranking Qualitative Assessment of Findings 10	Above Average 9	8	7	6	Average (Mid-level ranking) Assessment of Findings 5	Below Average 4	3	2	1	Lowest Ranking Qualitative Assessment of Findings 0	Comments
Electric Utility Service	H	10											Power Description from Alternative Site Selection Summary
Fiber – Copper Availability	H		9										Communications Infrastructure Availability
Planning / Zoning (state / local incentives)	M	10											Present Zoning Conditions / Variances required
Site Environmental Requirements	H	10											Environmental Study Required?
Useable Gross Acres Available, Topography	M				7								Five (5) acres minimum
Natural Hazards (Flooding, Hazardous Weather, Seismic)	M			8									Information from Site Selection Summary document
Man-Made Hazards (highways, rail, airport)	M					6							From Site Selection Summary document
Cost of Site	L	10											Market valuation / site development
Scoring Total	**70**												

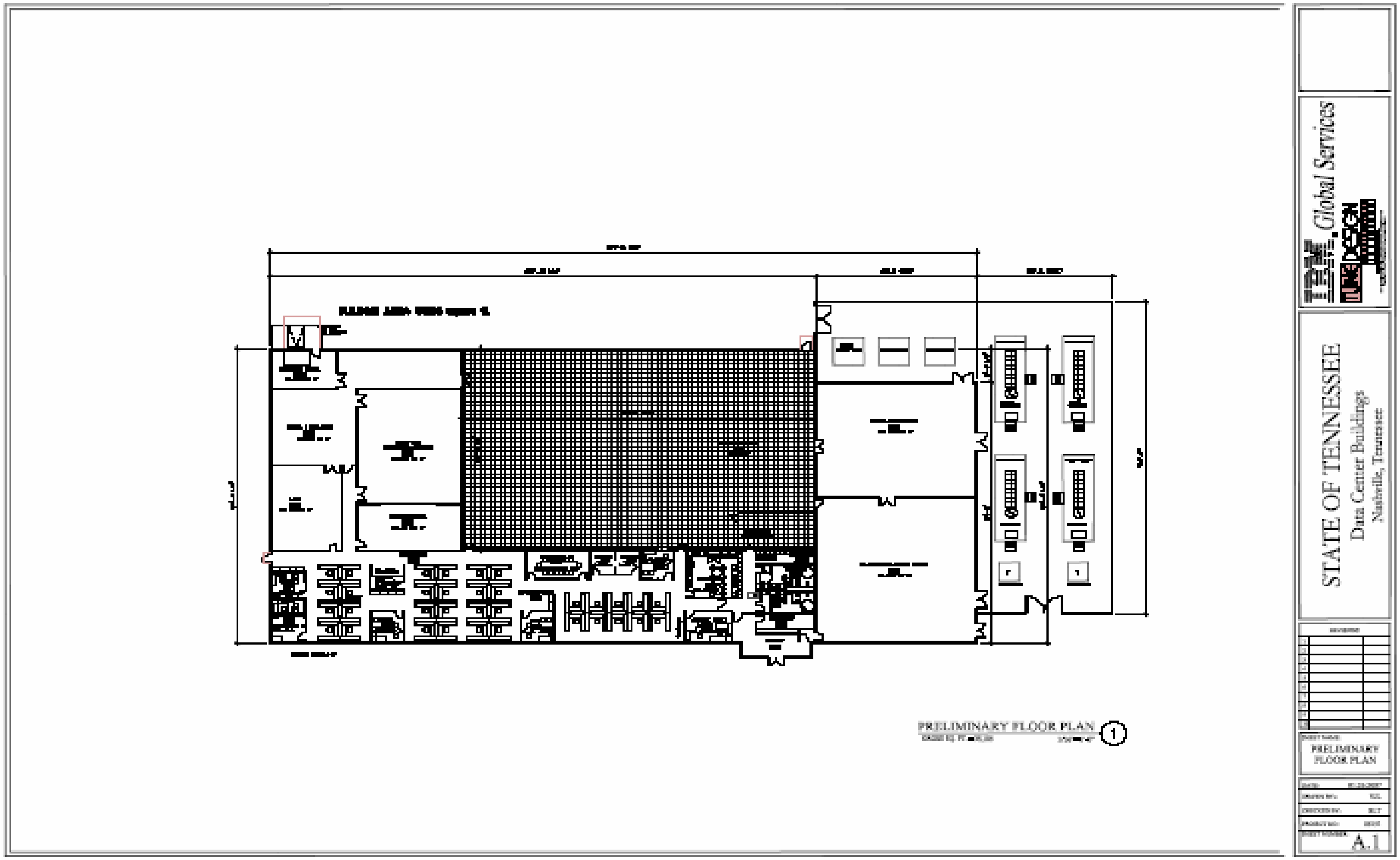
Un-Weighted Score - State of the Art 69-80, Above Average 54-68, Average 40-53, Below Average 0-39

Site Name and Location: 4433 Ashland City Hwy., Nashville, TN 37218

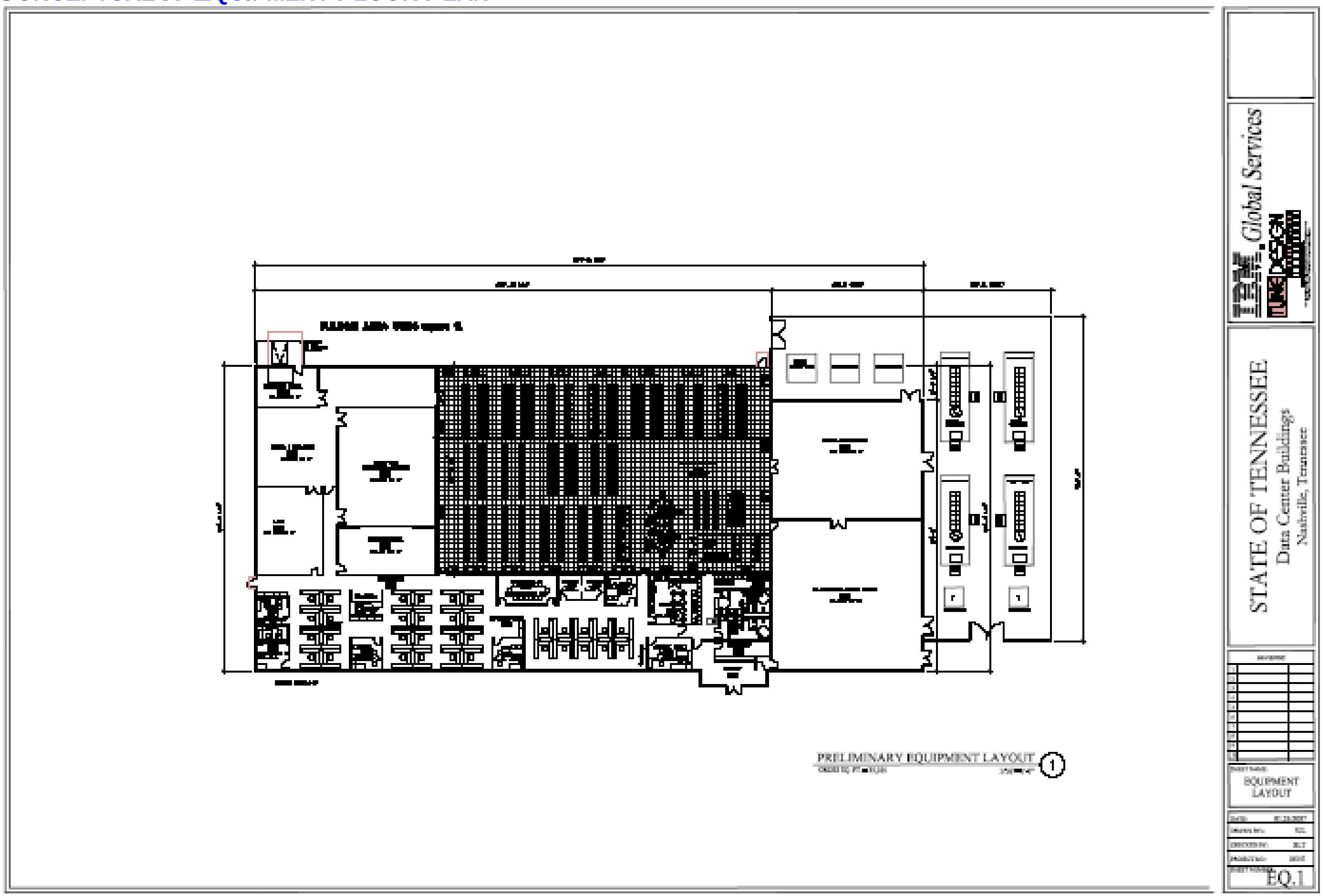
Factor or Consideration	Weight Factor High Medium Low	Top Ranking Qualitative Assessment of Findings 10	Above Average 9	8	7	6	Average (Mid-level ranking) Assessment of Findings 5	Below Average 4	3	2	1	Lowest Ranking Qualitative Assessment of Findings 0	Comments
Electric Utility Service	H				7								Power Description from Alternative Site Selection Summary
Fiber – Copper Availability	H			8									Communications Infrastructure Availability
Planning / Zoning (state / local incentives)	M				7								Present Zoning Conditions / Variances required
Site Environmental Requirements	H				7								Environmental Study Required?
Useable Gross Acres Available, Topography	M					6							Five (5) acres minimum
Natural Hazards (Flooding, Hazardous Weather, Seismic)	M			8									Information from Site Selection Summary document
Man-Made Hazards (highways, rail, airport)	M							4					From Site Selection Summary document
Cost of Site	L					6							Market valuation / site development
Scoring Total	**53**												

Un-Weighted Score - State of the Art 69-80, Above Average 54-68, Average 40-53, Below Average 0-39

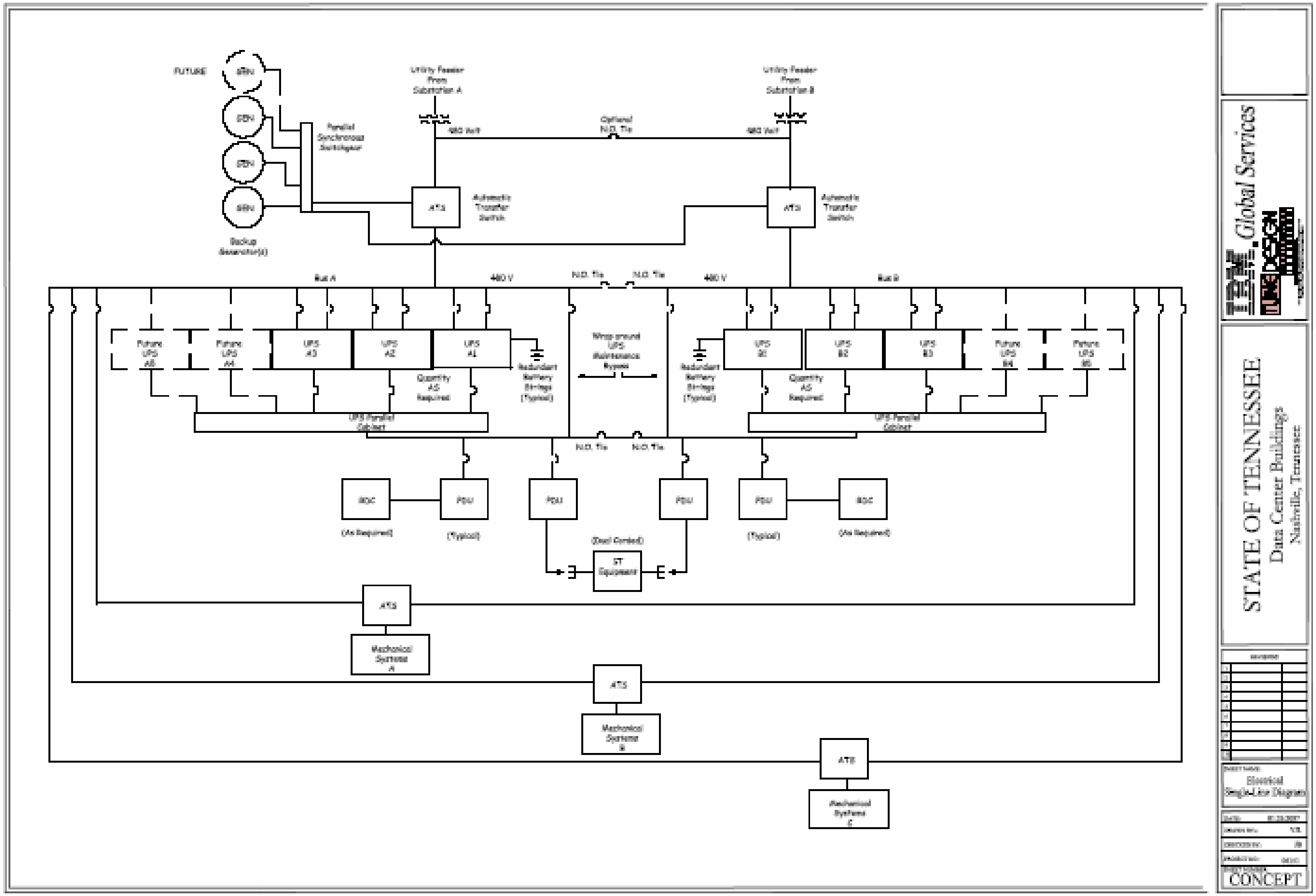
Conceptual Building Plan



Conceptual IT Equipment Floor Plan



SINGLE LINE ELECTRICAL DRAWING



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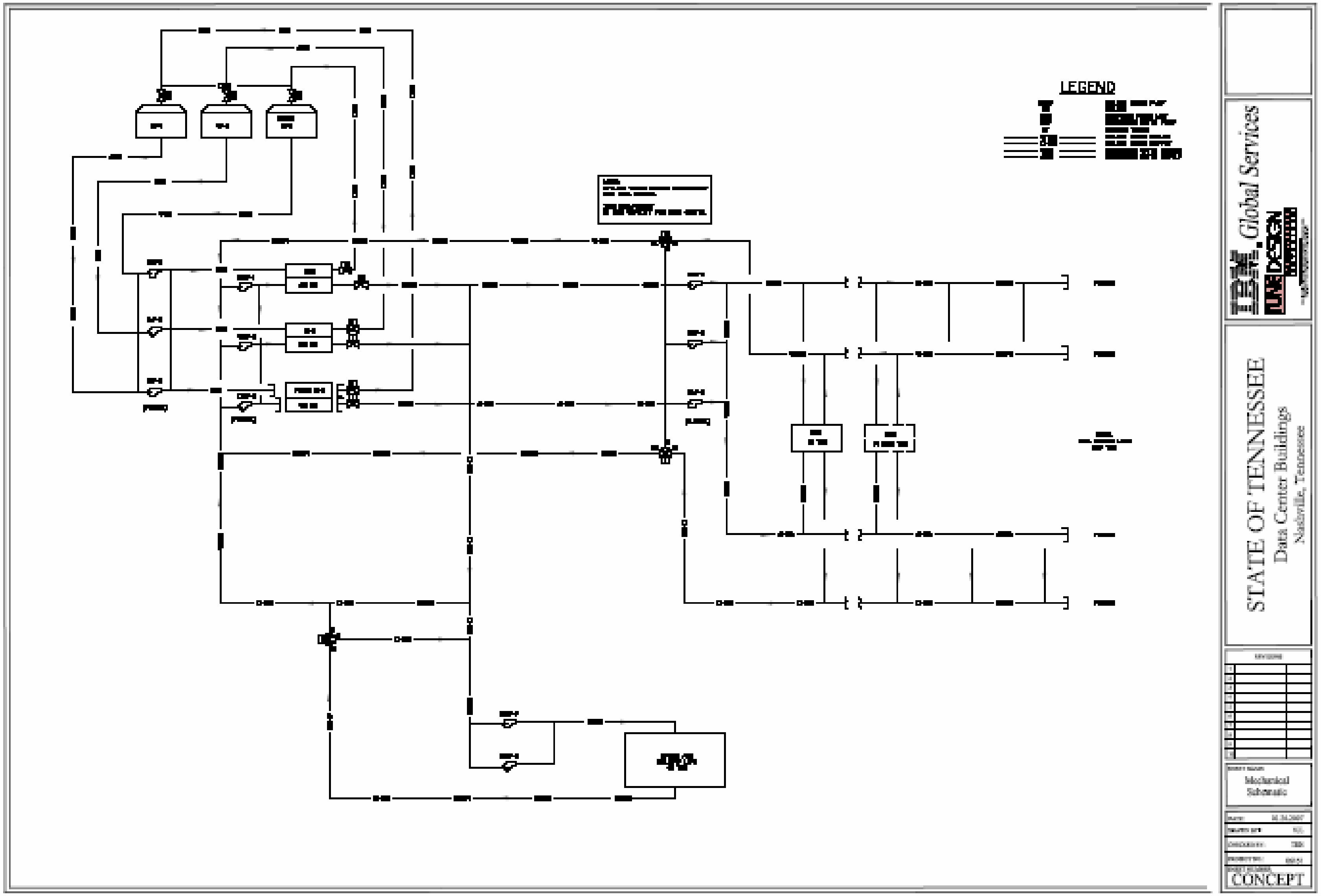
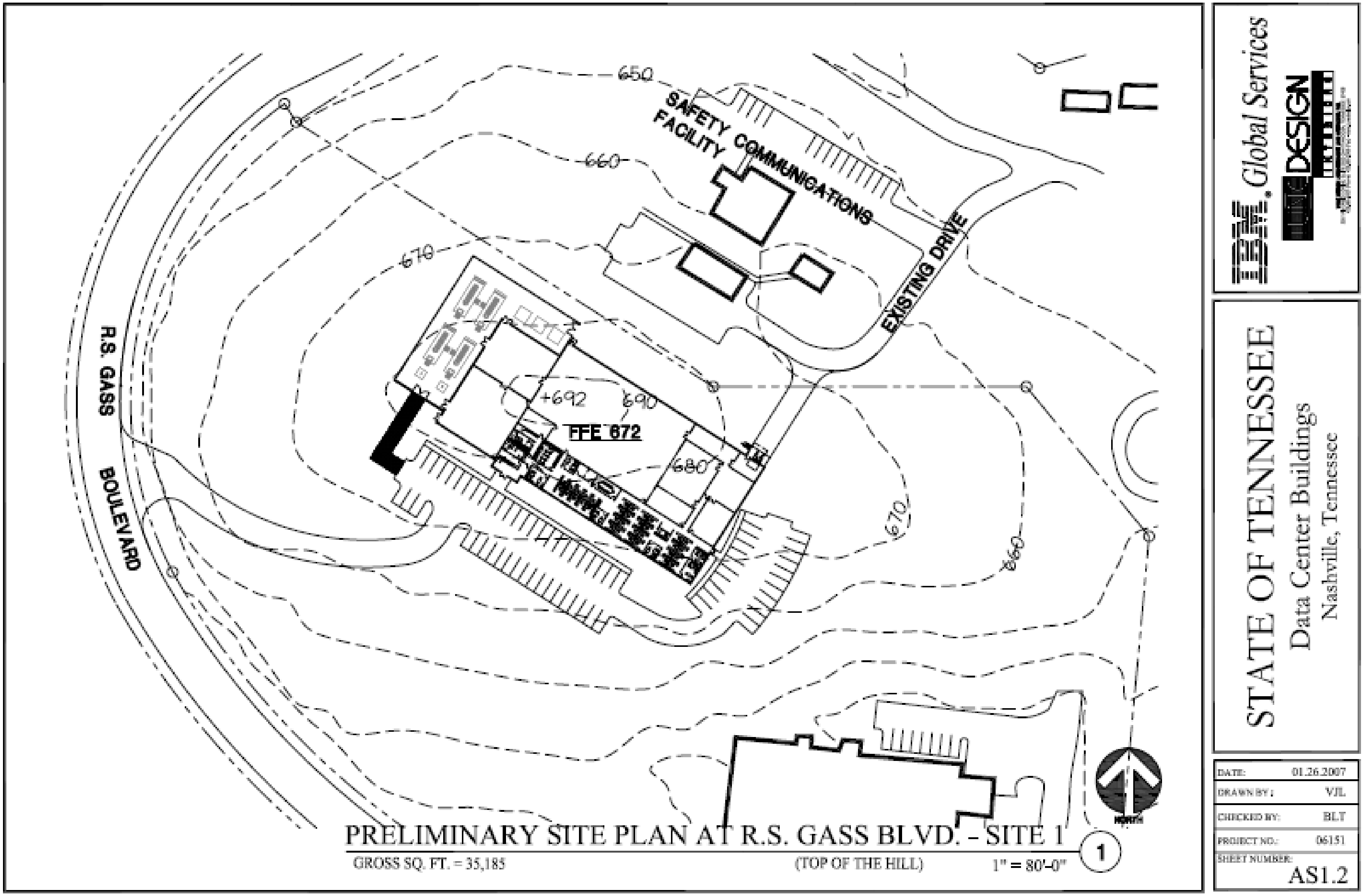
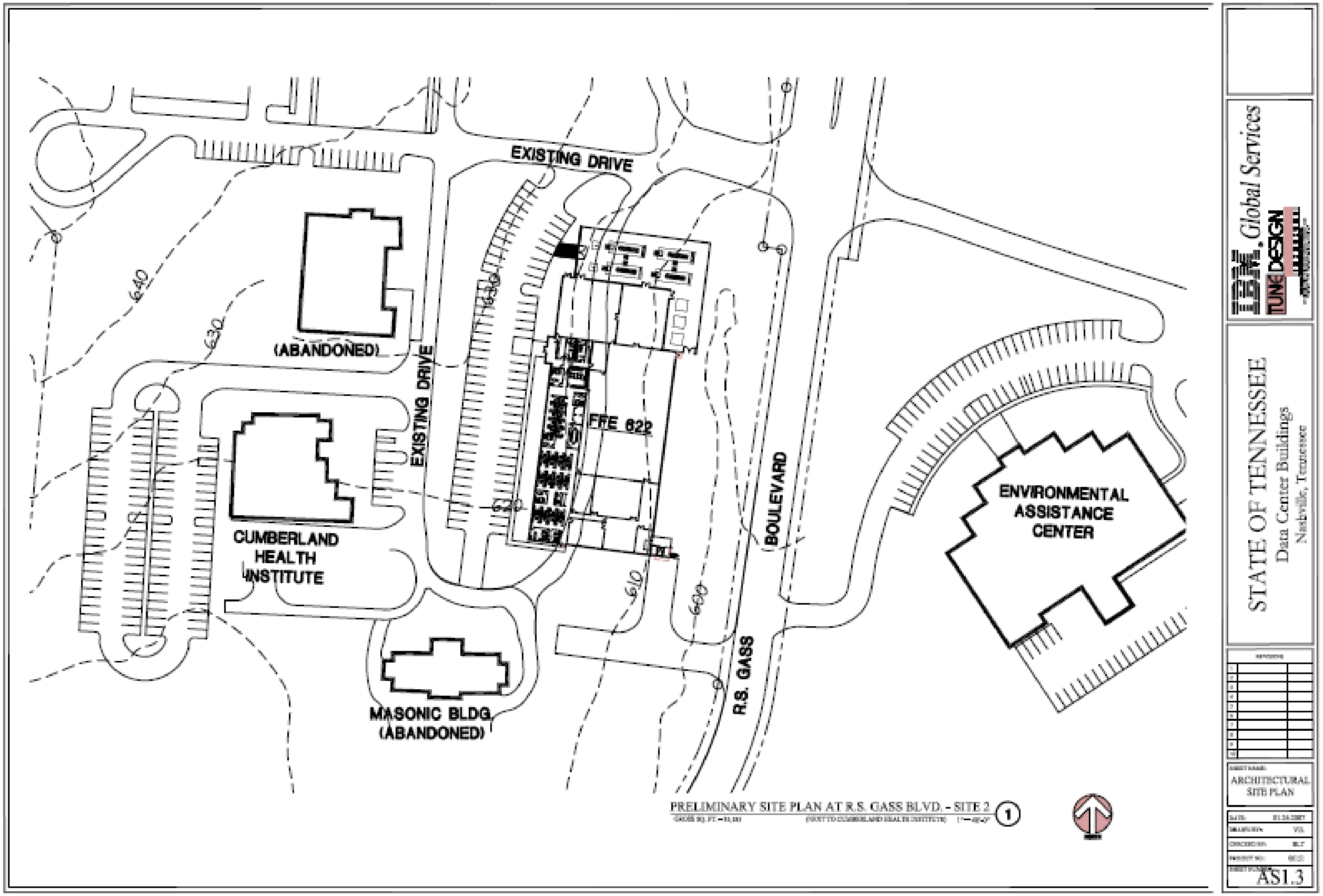


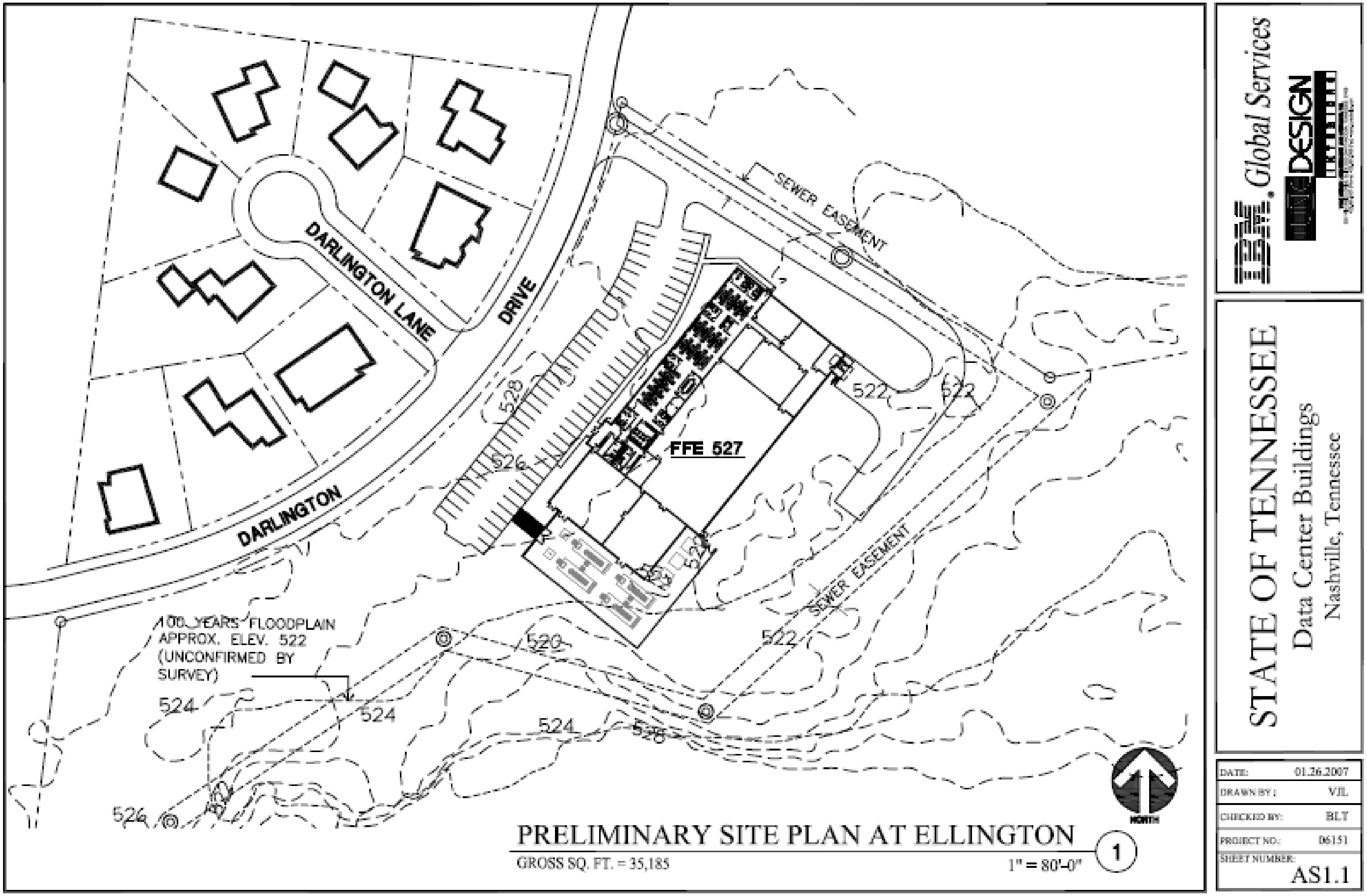
BUILDING PLOT PLAN – RG GASS HILLTOP SITE



Building Plot Plan – RG Gass Masonic Home Site



BUILDING PLOT PLAN – TWRA ELLINGTON SITE



BUILDING PLOT PLAN – SYMRNA AIRPORT SITE